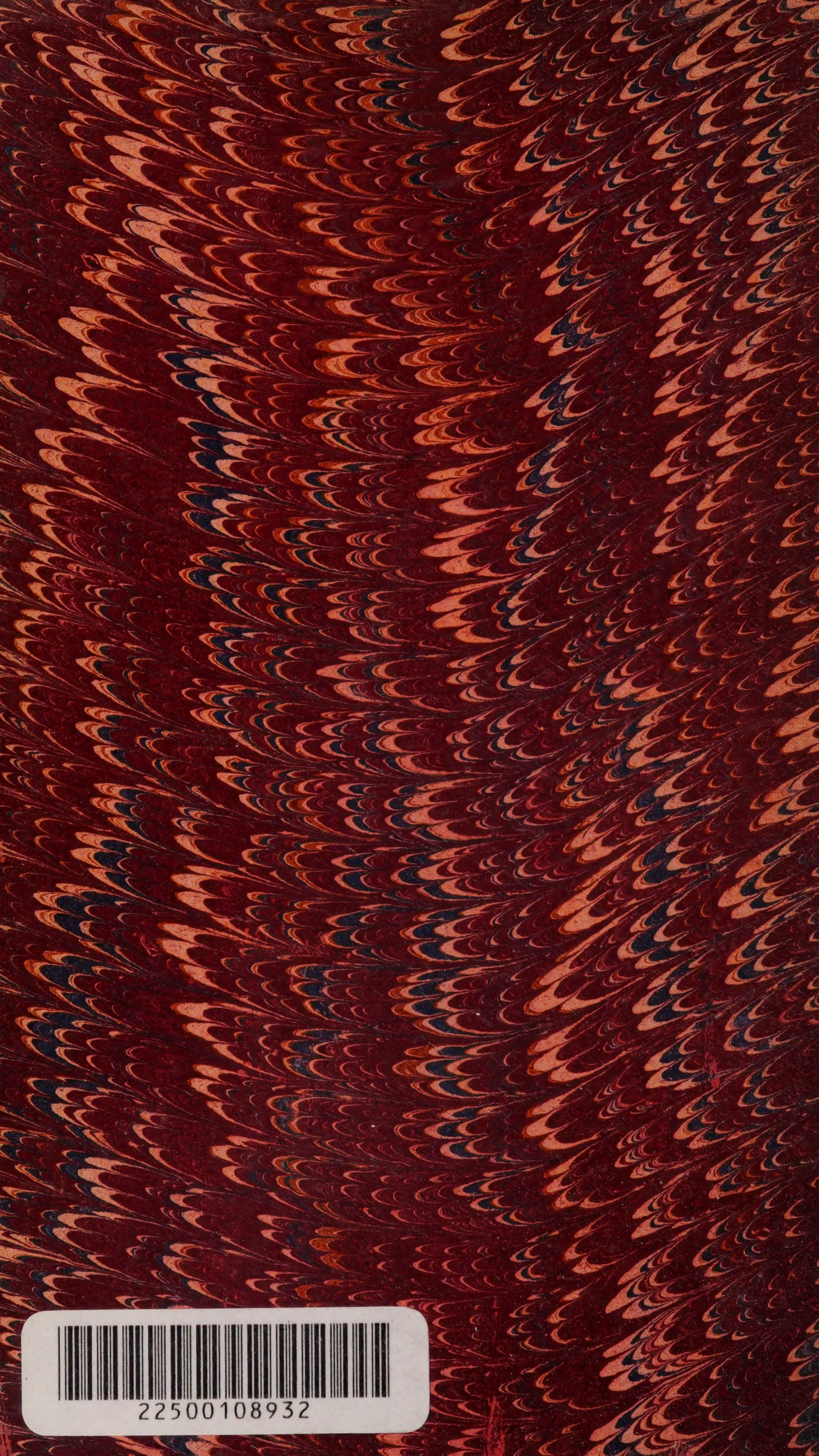
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TWENTY-FIRST ANNUAL REPORT

OF

THE LOCAL GOVERNMENT BOARD,

1891–92.

SUPPLEMENT

CONTAINING THE

REPORT OF THE MEDICAL OFFICER

For 1891–92.

Presented to both Houses of Parliament by Command of Her Majesty.

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PUBLIC HEALTH.

ANNUAL REPORT

OF THE

MEDICAL OFFICER

OF

THE LOCAL GOVERNMENT BOARD

FOR THE YEAR

1891-92.

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REPORT.

TO THE RIGHT HONOURABLE THE PRESIDENT OF THE LOCAL GOVERNMENT BOARD.

SIR,

I HAVE the honour to lay before you the following Report on the special work of the Medical Department during the year ended Lady Day 1892. That work was carried out under the direction of my predecessor, Dr. (now Sir George) Buchanan, and for this reason I submit it without any lengthy comments.

The series of which this volume forms a part was originated under the Privy Council in 1859 by Sir John Simon; it was maintained for a brief term of years by the late Dr. Seaton, and has been continued since 1880 by Sir George Buchanan. It embodies the history of medicine in its practical and scientific aspects as applied to public health and the prevention of disease in England and Wales, and it records a progress which is admitted to stand unique amongst the nations. The progress in question is largely identified with the labours of those who have heretofore held the post of Medical Officer to the Board, and in recording the resignation of Sir George Buchanan at the end of March 1892 I cannot do otherwise than recall the distinguished services which he has rendered to the cause of public health in this country.

For over 30 years Sir George Buchanan has, either as Medical Inspector or as the Board's Medical Officer, contributed to the Annual Reports of the Medical Department, and many of his contributions have become classic in the literature of public health both in this and in other countries. But those alone who have had the opportunity and pleasure of working under his direction can appreciate to the full the important influence for good which his labours have had; and they alone can realise how much the Medical Department owes to the example which he set as an earnest worker and director, who never ceased to claim that all true sanitary progress must be based on accurate and scientific research into the etiology of disease.

The Board have done me the honour of appointing me to succeed the distinguished men who have already held the post of Medical Officer, and it will be my earnest endeavour to maintain at its present standard the Department thus committed to my direction.

During the year 1891, to which this Report relates, the Medical Department lost the services of two of its most able and experienced Inspectors. Dr. Blaxall, R.N., and Dr. Ballard, F.R.S., both retired after having rendered long and valued service to

the Board; and the vacancies thus created were filled by the appointment of Dr. S. A. M. Copeman and Dr. W. W. E. Fletcher as Medical Inspectors to the Board.

I.—ADMINISTRATIVE RELATIONS OF THE MEDICAL DEPARTMENT.

1. Vaccination and Public Vaccination.

The digest of the Vaccination Officers' returns with regard to children whose births were registered in England and Wales during the year 1889 shows that 9·9 per cent. of those births were not finally accounted for, this per-centage including 1·7 per cent. of children whose vaccination was postponed under medical certificate and 0·2 per cent. who were returned as having had small-pox or as being "insusceptible" of vaccination. Separating the returns into metropolitan and provincial, the per-centages not finally accounted for were 11·6 for the metropolis and 9·6 for the provinces. Both these rates indicate a further increase in the amount of failure to comply with the law relating to vaccination, a circumstance which becomes serious in view of the growth of small pox which is in progress in many parts of the country. (Appendix A., No. 1.)

During the year 266 unions were inspected for the purposes of public vaccination. The number of vaccination districts involved was 1,256, and in 809 instances recommendations for awards were made as regards the public vaccinators concerned. (Appendix A., No. 2).

National Vaccine Establishment.—During the year 1891 the Board lost, through death, the services of Mr. W. E. Grindley Pearse, one of the public vaccinators in the metropolis authorised to grant certificates of proficiency in vaccination to persons whom they have instructed. He was succeeded by Mr. Joseph Loane, who on appointment was further authorised to give such certificates, after satisfactory examination, to qualified medical practitioners whom he has not himself instructed.

Details are given in Appendix A., No. 3, as to the sources and amount of humanized lymph received during the year. For such lymph 5,116 applications were received, and in reference to them 7,610 capillary tubes and 284 charged ivory points were sent out.

The supplies of calf lymph received from the Board's Animal Vaccine Establishment amounted to 14,002 charged ivory points and 56 capillary tubes; all the capillary tubes, and 13,977 of the charged points being sent out to applicants for such lymph.

In recording the operations of the Animal Vaccine Station, (Appendix A., No. 4.), Dr. Cory gives some interesting details as to the body temperature of calves and infants under vaccination, and he is inclined to regard the observed later appearance

in the infant than in the calf of a maximum rise of temperature while under vaccination, as having relation to the earlier maturation of the vaccine vesicle in the bovine as opposed to the human animal. Primary vaccination was performed at the station on 7,529 persons; and out of 7,448 who returned for inspection, the vaccination was successful in 7,430 cases at the first attempt. In no case was a third attempt at vaccination requisite to success. The re-vaccinations numbered 321.

The Royal Commission on Vaccination which commenced its sittings on June 26th, 1889, has been almost continuously engaged since that date in taking evidence on the subject. Those sittings are still in progress.

2. Other Administrative Business of the Medical Department.

Conferences have in a number of instances been held at the office between the Board's officers and representatives of local authorities on such questions as the provision of means of isolation for the infectious sick, and the preparation of codes of byelaws. In 14 instances local inquiries of a like sort were held.

Detailed local investigations were also made by Inspectors of the Medical Department, involving 50 sanitary districts (*see* Appendix A., No. 5). These inquiries were, in the main, brought about by the occurrence of outbreaks of disease in the districts concerned; but in many instances the efficiency of the local sanitary administration was also involved, and in some cases it was this question which essentially governed the inquiry.

Complaint by County Council.

In four instances inquiries of the latter sort were undertaken on receipt by the Board of representations from the West Riding County Council, to the effect that the Public Health Act, 1875, had not been properly administered by the respective sanitary authorities. The districts in question were the Cumberworth, Hepworth, Kirkheaton, and Lepton urban districts; as regards each, a detailed report was made to the Board by Dr. Barry, and the result went fully to confirm the view taken by the County Council. Already some substantial action has been taken or initiated on the lines indicated in Dr. Barry's reports; but the Board are still in communication with some of the authorities concerned as to the need for adopting further measures with a view to the efficient sanitary administration of their districts. In the case of Kirkheaton, the Board found it necessary to issue an Order under section 42 of the Public Health Act, 1875, requiring the urban sanitary authority to undertake or contract for the removal of house refuse, the cleansing of privies, &c., a duty which had hitherto been left to occupiers. The report on the Kirkheaton urban district is reproduced in the Appendix (A., No. 6) as typical of this series of reports.

Epidemic Influenza.

Amongst the diseases which were made the subject of special inquiry during the year Influenza again occupied a prominent

Medical Officer's Report.

position. The circumstances attending the epidemic of 1889–90 were dealt with in a separate report, and the further investigations which have been made as to the distribution and etiology of the disease during 1891–92 will, in like manner, be submitted in separate form.

Enteric fever in the Tees Valley.

In dealing with the proceedings of the Medical Department during 1890, Sir George Buchanan presented an interim report by Dr. Barry on an outburst of enteric fever in the Tees valley; the special incidence of the disease having been upon consumers of water derived from the Tees at a point below that at which the river was subject to abundant excremental pollution. Whilst engaged in analysing in greater detail the evidence as to the cause of this epidemic, a renewed outburst of the disease took place under circumstances that give additional importance to this remarkable prevalence of fever. Dr. Barry's further report, which had to be delayed until after the census enumeration returns of 1891 were available, will appear in folio form as a separate supplement, this arrrangement having been found requisite owing to the number and size of the diagrams and tables, by means of which it was necessary to illustrate the completed report.

An account by Dr. Bruce Low of Anomalous Illness characterised by pneumonia, and sometimes by meningeal symptoms, frequently associated with tonsillitis and sore-throat, is of particular interest in reference to previous observations by this inspector in certain eastern counties of localised occurrences of cerebro-spinal meningitis (Appendix A., No. 7). Though with regard of the Northamptonshire illness dealt with in this report, cerebro-spinal symptoms were by no means the rule, yet certain cases and groups of cases had much in common with the East Anglian attacks of the previous year; and generally the facts were not without suggestion of the operation during successive years in different quarters of England of a like cause of illness of "cerebro-spinal" type. Whether or not Influenza had concern with the anomalous illness in question could not be determined.

Scarlatina.

Amongst the outbreaks of infectious diseases investigated during 1891 was a prevalence of scarlatina at Bush Hill Park, an estate of 370 houses, situated partly in Enfield and partly in Edmonton. The outbreak was, according to Dr. Copeman's Report (Appendix A., No. 8), limited to eight consecutive days in November, and the only community of condition amongst households affected was their milk supply. This milk was derived from a farm at some distance in Essex, where attacks of the same disease occurred amongst consumers of milk from the same farm. No infection of the milk from a human source could be made out, but the cows were found to be suffering from udder eruption. Incidentally the report shows a different attitude on the part of the milk retailer at Edmonton, and of the farmer who supplied him with the infected milk. Both were incredulous as to the milk having had concern with the scarlatina; but whilst the local tradesman, in effect, refused assistance in elucidating the

question as to the influence of the milk on the outbreak, the Essex farmer willingly gave intelligent assistance to this end. The Board were only able to bring the cow-malady under Dr. Klein's observation, for biological purposes, in the declining stages of the malady, and the inoculations of calves with matter from a single ulcer which were carried out afforded only negative results. The same material on culture did indeed afford a streptococcus which morphologically and culturally resembled that isolated in 1885–86 from Hendon cows, but this organism on inoculation into mice proved only doubtfully pathogenic.

Town manures.

Numerous complaints having reached the Board, from various quarters, as to nuisance and injury to health in connexion with the transport of town manure into agricultural districts, Dr. Parsons received instructions to inquire into the circumstances of this traffic, and he has submitted an exhaustive report on the subject (Appendix A., No. 9). Two principal objects were held in view during the inquiry. In the first place it was desired to learn how far allegations as to injury to health, and even as to the production of definite disease, as the result of exposure to the emanations of town manure, were supported by actual experience. And, in the second place, it was sought to ascertain how far nuisance owing to the unloading and temporary deposit of the manure at railway sidings and elsewhere, and owing to lack of care in the process of carting along public thoroughfares, could be dealt with by the aid of existing statutes and byelaws; or called for new regulations, under byelaws or otherwise, such as could be contrived without placing undue restriction either on Sanitary Authorities having a duty to dispose of such material, or on agriculture.

"London manure" occupied a prominent position in connexion with these complaints. It is, as a rule, entirely free from human excreta, but it is otherwise a compound of nearly every form of animal and of some forms of vegetable refuse; such materials as dead and putrefying animals, fishguts, paunches, &c., being mingled with stable manure, cabbage stalks, rotten vegetables, &c. And the diseases which were most commonly regarded as being referable to the offensive emanations were diphtheria and allied sore-throat.

The first point is dealt with at considerable length in the report, and the outcome of the inquiry may be held to show :— 1°, that in so far as bodily discomfort and functional disturbance, at times involving general impairment of health, are concerned, exposure more or less recurring to the offensive effluvia concerned, does affect health; and 2°, that whilst certain affections such as "sore-throat," which it has not always been possible to differentiate from diphtheria, can with some degree of certainty, be held to have relationship with exposure to the manure-effluvia in question, it has not been possible so to eliminate other sources of infection and of disease as to identify the effluvia with the production of any specific affection.

Medical Officer's Report.

With regard to the second part, Dr. Parsons has a number of valuable suggestions to make, and utilising the information which he has obtained the Board have, in advance of the issue of his report, drawn up a new byelaw dealing with the unloading and deposit of filth emitting stench in proximity to buildings used for human habitation or to places of public resort.

II.—AUXILIARY SCIENTIFIC INVESTIGATIONS.

Pathology and Etiology of diphtheria.

In continuation of his study of diphtheria, Dr. Klein has commenced investigation from a bacteriological view-point of the relations of that disease and croup (Appendix B., No. 1). Inquiry in this sense has been the more called for since "croup" is a term of uncertain pathological significance, notwithstanding its abundant employment in registration of cause of death in various parts of the country. Taking the presence of the Klebs-Löffler bacillus (*bacillus diphtheriæ*) in definite relation with lesion of the mucous membrane, as determining the nature of maladies not considered clinically identical, Dr. Klein has tested one and another throat ailment that offered itself for examination, and with results as follows:—He finds, as others have before him, that so-called "scarlatinal diphtheritis" occurring in the *early days* of scarlet fever attack, is not, judged from the bacteriological standpoint, diphtheria; and, on the other hand, that similar manifestations, whether of diphtheritic or croupy type, occurring in the *later stages* of and during *convalescence* from scarlet fever, are almost invariably true diphtheria. But he also finds, in the majority of cases examined by him, that membranous croup of the larynx or trachea, though altogether dissociated clinically from diphtheria, is to be regarded as essentially that disease; indeed, so far he has only met with a single instance of croup not related clinically to diphtheria or to scarlatina, in which he was unable, with the material at his disposal, to demonstrate the presence in the membrane of bacillus diphtheriæ.

Concurrent infections.

With reference to the Influence of one Infection upon another, Dr. Klein has, as in former years, studied not only the interrelations within the animal body of different microbic processes, but also the effect therein on the life processes of a given microbe of introduction of the metabolic products of a different microorganism.

Erysipelas and Vaccinia;

And *first*, as to *Erysipelas and Vaccinia* (Appendix B., No. 2); he sought to induce in the calf both these diseases. From the ears of a series of rabbits in which he had set up erysipelas, indifferently by inoculation of the raw material of that disease and of culture on gelatine of the streptococcus erysipelatos, he obtained active erysipelas infection in the form of serum expressed from the ears of the inoculated rabbits, as well as in the form of pure culture in gelatine of the erysipelas organism derived from the serum in question. These matters he inoculated,—by multiple cutaneous incisions of the skin in the groin and abdomen,

—into calves; but always with one result, namely, complete failure to induce erysipelas in these animals. He next tried, also in calves, simultaneous inoculation of the above material together with fresh calf lymph, and also inoculation of the one material antecedent to the other. But on each occasion he obtained the following uniform result: vaccinia never failed to take and to run its course in orthodox fashion, whereas his attempts to induce erysipelas along with, or in sequence to, the vaccinia, failed entirely and always. As a result of these experiments, Dr. Klein has come to regard calves as altogether insusceptible to erysipelas disease. His further experiments with living microbes included simultaneous inoculation of: (*a.*) the Aerobic bacillus of Malignant Œdema and the bacillus of Grouse Disease; (*b.*) the Grouse bacillus and the Middlesbrough Pneumonia bacillus; (*c.*) the bacillus of Mouse Septicæmia and bacillus of Swine Erysipelas; and (*d.*) the bacillus of Fowl Cholera and the bacillus of Fowl Enteritis. Mice, pigeons, and fowls were the animals experimented on in these series, but in series (*a.*) alone were positive results of the nature of antagonism between the organisms of experiment obtained. The Malignant Œdema bacillus and the Grouse bacillus when separately injected into mice were almost invariably alike fatal to these animals, and after an equal interval of time. But when cultures of these microbes were mingled together and the mixture injected into mice, the animals thus dealt with, almost without exception, easily survived, indeed very few of them suffered any illness.

products of bacillus pyocaneus.

Secondly, as regards the chemical products of bacteria in their inhibitory action within the animal body on the life processes of pathogenic organisms, Dr. Klein has (Appendix B., No. 3) made further study of *bacillus pyocyaneus* as affecting the development of tubercle. So long ago as the winter of 1889–90—antecedent to the announcement by Professor Koch of "Tuberculin" as a material inhibitory of tuberculosis in the guinea-pig—Dr. Klein was seeking to ascertain by experiment how far tuberculosis artificially induced in these animals could be retarded or controlled by subsequent repeated injection of the affected animals with sterilised cultures of the tubercle bacillus. But the results then obtained by him were negative; and, as noted in the report of the Medical Officer for 1890 (page viii), he was subsequently led to substitute in this connexion the chemical products of bacillus pyocyaneus for sterilsed culture of the tubercle bacillus. The "expectation that the chemical products "of bacillus pyocyaneus will be found to have distinct inhi- "bitory action on the tuberculous process," recorded by the Medical Officer in his report for 1890 has, as regards guinea-pigs, been fully borne out by the experience of 1891–92. Several separate series of these animals were inoculated by Dr. Klein, some with material of *human* some with material of *bovine* tubercle, with the effect of producing in each guinea-pig thus dealt with definite manifestation of commencing tuberculosis. As soon as tuberculosis was thus established in a

series of animals, certain of them were repeatedly injected during successive days now with dilute now with undilute sterilised cultures of bacillus pyocyaneus, while others were kept for control. As a result the control guinea-pigs invariably died in the usual time of their induced tuberculosis, whereas in the guinea-pigs which, after their inoculation with tubercle, had been subjected to injection of the products of bacillus pyocyaneus, the tuberculous process was found delayed or even arrested; indeed so uniformly in this way was definite inhibition of tuberculosis (especially when undiluted culture of bacillus pyocyaneus was injected in considerable amount at frequent intervals) obtained by him, that Dr. Klein sought a further and more satisfactory test of this new method of controlling the development of tubercle. Short of the human subject, the bovine animal seemed to promise the best test in this sense, and accordingly Dr. Klein proceeded to experiment further on cows and calves. Unfortunately, however, Dr. Klein's attempts at setting up, by subcutaneous inoculation of active bovine tuberculous matter, tuberculosis in these animals practically failed in four cows and two calves experimented on by him; and so far he has not been able to make further trial of the inhibitory power of bacillus pyocyaneus in the direction contemplated.

Chemistry of Diphtheria.

Proceeding on lines indicated by his former inquiry into the Chemistry of Anthrax, Dr. Sidney Martin has, in 1891–92, made investigation of the Chemical Pathology of Diphtheria and of Infective Endocarditis (Appendix B., No. 4). As will be remembered, Dr. Martin, in his former researches respecting anthrax, ascertained first of all what were the chemical products of bacillus anthracis in an artificial medium of unorganised materials representing as nearly as practicable blood-serum, and then went on to the discovery that identical chemical substances (albumoses and an alkaloid) were obtainable from the tissues of animals dead of anthrax. In 1891–92 he reversed his process of investigation, first inquiring what are the chemical substances abnormal to the tissues which are separable from the blood and spleens of persons dead of a given disease, and what the physiological action of such chemical substances when injected into rodents; afterwards proceeding to ascertain whether identical chemical products, with like physiological action on rodents, are obtainable from artificial media in which the reputed microbe of the particular disease has been under cultivation.

Dealing in this fashion with Diphtheria, Dr. Martin obtained alike from the blood and spleens of persons dead of that disease, from the diphtheria membrane of non-fatal cases, and from cultures in beef-broth of the Klebs-Löffler bacillus, albumoses and an organic acid which produced when injected into rodents definite physiological results of a nature parallel with those observed in the human subject attacked by diphtheria. Not least conspicuous among the physiological effects of these albumoses, and the more significant therefore as testimony to their essential "specificity," was production in Dr. Martin's

experimental animals of those nerve lesions which have obtained the name of diphtheria paralyses. And this circumstance has led to the pathological condition of the nervous system in man and in other animals associated with this paralysis, or rather paresis, being examined by Dr. Martin carefully and in much detail. He demonstrates it to be due to degeneration of the peripheral nerves (motor, sensory, and sympathetic), without implication of spinal cord, spinal ganglia, or brain; a degeneration, moreover, which he shows to be an early and direct result of diffusion in the experimental animal of the chemical products of diphtheria.

Of these chemical products Dr. Martin finds the albumoses far more potent physiologically than the organic acid, and it is to the albumoses of diphtheria that he would refer in the main the constitutional and neurotic manifestations of that disease. As to the sources of the poisonous albumoses, Dr. Martin points to some important indications that they, unlike the albumoses of anthrax, are not the direct outcome of the life processes of the bacillus with which they are associated, but are, so to speak, the product of its product. Thus, he found that an "extract of diphtheria membrane" with which he was experimenting, though it contained mere trace only of proto- and deutero- albumose, caused when intravenously injected in definite and single dose into rabbits, more profound physiological effect than larger and repeated doses of diphtheria albumoses obtained by him from the blood and spleen. Hence he infers the existence in the diphtheria membrane of a poison associated with, but distinct from, the proteid; a poison which has been, in his view, excreted by the diphtheria bacillus at the seat of its local multiplication in the throat of the affected patient. This poison Dr. Martin regards as in nature a *ferment*, which being absorbed into the system is able to digest the proteids of the body, with the result of production of poisonous albumoses and organic acid, such as were obtained by him from the blood and spleens of diphtheria patients. The ferment in question he would term the "secondary infective agent," in distinction from the primary infective agent which in his view, as in that of others, is the bacillus diphtheriæ.

Susceptibility and Insusceptibility.

Dr. Hamer, in continuation of his investigation of the Chemistry of Susceptibility and Insusceptibility (Appendix B. No. 5), has given attention to certain ferments proper to the animal body, with reference to their power of retarding or inhibiting multiplication of different microbes. He experimented first with human saliva, and he found that a weak solution of this saliva, provided it be not boiled, may, notwithstanding it has been inoculated with bacillus subtilis, be incubated almost indefinitely and yet remain free from growth of that organism; and on the other hand, he found that a similar solution dealt with in like manner, *but after boiling*, quickly develops abundant growth of bacillus subtilis. Next he obtained, by macerating a dog's pancreas in glycerine, a pancreatic extract which he added to different culture media in a series of test tubes, and

incubated the latter, after inoculation with various kinds of bacteria, at suitable temperatures. In this series, however, no definite restraining influence of the ferment on the growth of the bacteria was observable, and a like negative result was obtained in similar experiments with the blood-ferment. Incidentally in the course of his experiments, Dr. Hamer obtained a pancreatic extract, which though proved absolutely sterile by independent tests, nevertheless liquefied gelatine without development of scum, or turbidity, or flocculent material such as is usually associated with the growth of bacteria. The experience of a material capable of exhibiting ferment powers altogether apart from coincident growth and development in it of micro-organisms may, Dr. Hamer notes, prove of service in the study of the action of unorganised as contrasted with that of organised ferments.

Organisms and supurative processes.

The last paper of the series (Appendix B., No. 6) gives account by Dr. Andrewes of observation of pus in its effect on the vitality of bacteria. He sought to ascertain with respect to certain pathogenic and saprophytic micro-organisms how far pus is, as a culture medium, favourable or hostile to their life and multiplication. The samples of pus employed by him were from abscesses both acute and chronic; some samples contained, some did not contain, streptococcus; some had been sterilised by heat, others had not been sterilised; some were acid, and some were feebly alkaline. And the micro-organisms of experiment were the bacilli of anthrax and diphtheria, the hay bacillus, the proteus bacillus, bacillus prodigiosus, and staphylococcus aureus. These several microbes exhibited very different behaviour in pus as a culture medium, but for the most part they failed to multiply there. Among the pathogenic species, bacillus anthracis and bacillus diphtheriæ were found to be at opposite poles in this respect: the former, whether or not containing spores, failed under all conditions to multiply in pus, and indeed soon died out in that medium; whereas bacillus diphtheriæ not only maintained its vitality but actually multiplied in the pus into which it was introduced.

Influenza: its pathology.

Investigation has also been made under the direction of Dr. Klein into the clinical and pathological aspects of Epidemic Influenza. The results of these researches appear in the separate volume already referred to.

I have the honour to be,
Sir,
Your obedient Servant,
R. THORNE THORNE.

May 1893.

APPENDICES.

APPENDIX A.

No. 1.

DIGEST of the VACCINATION OFFICERS' RETURNS, with regard to CHILDREN whose BIRTHS were registered in the Year 1889.

THE following is the eighteenth annual return under the Vaccination Act, 1871. Of 885,909 births returned to the Board by the several Vaccination Officers in England and Wales as registered during the year 1889, the number which at the time the return was made had been registered as successfully vaccinated was 707,161. This number is 79·8 per cent. of the whole. The children whose births were registered during the year, and who were not recorded as successfully vaccinated, numbered 178,748. Of this number, 88,995 were registered as having died unvaccinated.* Out of the same number, 1,758 had been registered as insusceptible of vaccination; 2 as having contracted small-pox and, therefore, not needing to be vaccinated; 13,366 as having their vaccination postponed by medical certificate; and there remained on the Vaccination Officers' registers 74,627 children born in 1889, who had "removed," were "not to be traced," or were otherwise unaccounted for. If from the 885,909 births returned by these officers deduction of the deaths without vaccination be first made, it appears that of the remaining 796,914 children, there were registered at the time of the return 88·7 per cent. as successfully vaccinated; 0·2 per cent. as either insusceptible of vaccination, or as having had small-pox; and 1·7 per cent. as under medical certificate of postponement; leaving 9·4 per cent. as at that time still unaccounted for as regards vaccination.

The per-centage of children not finally accounted for as regards vaccination (*i.e.*, including cases postponed) was 9·9 of the total births (885,909); and this figure is given in the table following, in sequence to the records of former years.

By the latter method of computation, it appears that the proportion of cases not finally accounted for in the metropolitan returns for 1889 was 11·6 per cent.; in the provincial returns, 9·6. Of the registered births of the eighteen years 1872–89, the corresponding proportion not finally accounted for in regard to vaccination in each year respectively has been as follows:—

—	Metropolis.	Rest of England.	—	Metropolis.	Rest of England.
1872	8·8	4·5	1881	5·7	4·3
1873	8·7	4·2	1882	6·6	4·5
1874	8·8	4·1	1883	6·5	4·9
1875	9·3	3·8	1884	6·8	5·3
1876	6·5	4·0	1885	7·0	5·5
1877	7·1	4·1	1886	7·8	6·1
1878	7·1	4·3	1887	9·0	6·7
1879	7·8	4·5	1888	10·3	8·2
1880	7·0	4·5	1889	11·6	9·6

In 1889 the proportion of cases unaccounted for, after deduction of the postponed cases, in the metropolis and in the rest of England, was 10·1 and 8·1 per cent. respectively.

* Of vaccinated children, dying before the returns are made up, no separate record is kept.

Note.

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Digest of Vaccination Officers' Returns, 1889.

As in recent Reports, I am desirous of here calculating, upon such data as are available, the number of children who, at the time the Vaccination Officers' Returns are made up, pass into the vaccinated class of the population, and the number that pass into the unvaccinated class. The result expressed in per-centages of the two classes cannot, I know, be absolutely correct; but I have satisfied myself that it cannot differ from the truth by more than a fraction of a unit per cent.

Vaccination Officers' Returns are made up to January 31st of the year but one following that to which returns relate. The interval between birth and return must therefore always be a twelvemonth and something more. This "something more" may be as little as one month, or as much as 13 months, according as the child is born at the beginning or the end of a calendar year:—the mean of the one and 13 months is seven months. [The following has reference to the Returns now presented.]

Let us as a first step examine the total mortality so far as recorded by the Registrar-General for the above period of childrens' lives, and apply our examination to the case of children born in 1889. We may take as a fair approximation to the mortality of children born in 1889 and dying during the first twelvemonth of life, the mean mortality at ages 0–1 of the years 1889–90; namely, 129,076.

We may take as a fair approximation to the mortality of children born in 1889, surviving their first year and dying in the course of 1–13 months afterwards, seven-twelfths of the mortality at ages 1–2 of the year 1890; namely: $\frac{7}{12} \times 41{,}576 = 24{,}253$.

The sum of the two figures 129,076 and 24,253 (viz.:—153,329) represents then with sufficient accuracy the total mortality occurring up to January 31st, 1891, among the children born in 1889. But the births of 1889 numbered 885,909, and therefore there remains a balance of 732,580 children, vaccinated and unvaccinated together, born in 1889 and surviving January 31st, 1891.

As a second step let us examine the returns of the Vaccination Officers made up to January 31st, 1891, and relating to the births of 1889. We find there a record of 88,995 deaths known to have occurred among unvaccinated children.

We find from the same returns a number of children born in 1889, and recorded as neither dead nor vaccinated on January 31st, 1891. The number of these unvaccinated survivors at the date in question was 89,753.

The difference between the total survivors and the unvaccinated survivors represents the number of children born in 1889 who, having been vaccinated, survived January 31st, 1891, the date to which Vaccination Officers' returns for 1889 are made up. This number is 642,827; vaccinated survivors.

[These numbers no doubt may deviate a little on one or the other side, from the precise number of deaths and survivals; but the deviations cannot be very large, and some of them would seem compensatory of each other.]

On February 1st, 1891, therefore, the survivors of those born in 1889 were pretty closely as follows:—

Vaccinated children - -	642,827	731,580
Unvaccinated children - -	89,753	

or, per cent. of all survivors,

Vaccinated children - - - -	87·8
Unvaccinated children - - - -	12·2

[I have said "pretty closely"; and a judgment may be formed of the extent of any probable error by noting that the transfer of 1,000 from the one to the other number would alter the respective per-centages by less than a quarter per cent.]

This per-centage 12·2 is made up of—

0·2 per cent. (1,760) certified as insusceptible of vaccination or as having already had small-pox.

1·8 ,, (13,366) vaccination postponed by medical certificate.

10·2 ,, (74,627) unaccounted for.

	Returns, 1889.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Died unvaccinated.	Vaccination postponed.	Remaining.	Children not finally accounted for (including cases postponed), per cent. of births.
ENGLAND & WALES -	885,909	707,161	1,758	2	88,995	13,366	74,627	9·9
Ditto (excluding Metropolitan Unions).	753,636	603,231	1,331	2	76,391	11,396	61,285	9·6
Metropolitan Unions -	132,273	103,930	427	—	12,604	1,970	13,342	11·6
COUNTIES.								
England:								
Bedford - - -	4,804	3,002	8	—	523	86	1,185	26·5
Berks - - -	7,544	6,487	12	—	535	151	359	6·8
Bucks - - -	4,644	4,100	3	—	344	52	145	4·2
Cambridge - -	5,564	4,794	11	—	453	88	218	5·5
Chester - - -	20,693	17,750	51	—	2,093	223	576	3·9
Cornwall - - -	8,988	7,172	7	—	918	189	702	9·9
Cumberland - -	8,237	6,814	3	—	825	208	387	7·2
Derby - - -	13,340	10,965	25	—	1,287	182	881	8·0
Devon - - -	17,631	14,915	24	1	1,620	351	720	6·1
Dorset - - -	5,237	4,535	6	—	361	84	251	6·4
Durham - - -	35,778	28,445	30	—	4,029	542	2,732	9·2
Essex - - -	23,166	19,010	64	—	1,832	481	1,779	9·8
Gloucester - -	15,677	11,661	37	—	1,465	371	2,143	16·0
Hereford - - -	2,995	2,586	4	—	255	40	110	5·0
Herts - - -	7,039	5,829	9	—	537	94	570	9·4
Hunts - - -	1,413	1,263	—	—	106	13	31	3·1
Kent (extra-metrop.) -	22,844	19,223	41	—	1,872	440	1,268	7·5
Lancaster - -	129,770	101,233	274	—	14,753	1,761	11,749	10·4
Leicester - - -	12,191	5,112	13	—	1,712	70	5,284	43·9
Lincoln - - -	13,698	11,373	19	—	1,483	245	578	6·0
Middlesex (ex.-metro.)	15,650	12,721	72	—	1,281	187	1,389	10·1
Monmouth - -	9,033	7,587	5	—	921	167	353	5·8
Norfolk - - -	13,221	10,913	22	—	1,277	163	846	7·6
Northampton - -	9,177	5,285	3	—	967	183	2,739	31·8
Northumberland -	15,741	12,941	22	—	1,854	363	561	5·9
Nottingham - -	16,378	12,788	32	—	1,866	297	1,395	10·3
Oxford - - -	5,450	4,358	7	—	486	114	485	11·0

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Digest of Vaccination Officers' Returns, 1889.

—	Returns, 1889.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Died unvaccinated.	Vaccination postponed.	Remaining.	Children not finally accounted for (including cases postponed), per cent. of births.
COUNTIES—*cont.*								
ENGLAND—*cont.*								
Rutland	566	496	1	—	49	4	16	3·5
Salop	7,184	6,268	6	—	613	94	203	4·1
Somerset	14,490	11,828	33	—	1,240	427	962	9·6
Southampton	18,600	15,990	25	—	1,412	234	939	6·3
Stafford	32,649	26,828	44	1	3,771	341	1,664	6·1
Suffolk	10,989	9,426	20	—	841	182	520	6·4
Surrey (extra-metro.)	14,952	12,117	36	—	1,196	375	1,228	10·7
Sussex	14,028	11,404	23	—	1,108	266	1,227	10·6
Warwick	24,403	20,261	55	—	2,479	226	1,382	6·6
Westmorland	1,838	1,617	1	—	141	22	57	4·3
Wilts	7,295	6,340	5	—	510	137	303	6·0
Worcester	17,958	15,578	36	—	1,721	135	488	3·5
York, East Riding	12,615	10,262	47	—	1,456	103	747	6·7
York, North Riding	10,788	8,887	11	—	1,164	246	480	6·7
York, West Riding	74,277	54,421	143	—	8,598	790	10,325	15·0
WALES:								
Anglesey	903	787	—	—	85	8	23	3·4
Brecknock	1,517	1,266	3	—	161	26	61	5·7
Cardigan	1,685	1,484	—	—	137	19	45	3·8
Carmarthen	3,976	3,545	—	—	357	33	41	1·9
Carnarvon	3,082	2,638	—	—	270	64	110	5·6
Denbigh	2,503	2,116	7	—	271	66	43	·4
Flint	2,324	1,979	3	—	209	41	92	5·7
Glamorgan	22,615	19,272	27	—	2,355	254	707	4·2
Merioneth	1,784	1,526	1	—	162	64	31	5·3
Montgomery	1,852	1,614	—	—	161	27	50	4·2
Pembroke	2,389	2,038	—	—	227	47	77	5·2
Radnor	471	381	—	—	42	20	28	10·2

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METROPOLITAN UNIONS.	Returns, 1889.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Died unvaccinated.	Vaccination postponed.	Remaining.	Children not finally accounted for (including cases postponed), per cent. of births.
Bethnal Green - -	4,961	3,224	—	—	490	53	1,194	25·1
Camberwell - - -	7,331	5,679	19	—	713	180	740	12·5
Chelsea - - -	2,968	2,472	11	—	307	18	160	6·0
Fulham - - -	5,982	4,982	48	—	595	48	309	6·0
George, St., Hanover Sq. -	3,227	2,807	14	—	277	8	121	4·0
George, St., in the East -	1,850	1,528	4	—	198	2	118	6·5
Giles, St., and St. George -	1,202	828	1	—	102	1	270	22·5
Greenwich - - -	5,425	4,208	20	—	573	137	487	11·5
Hackney - - -	6,744	4,931	20	—	544	74	1,175	18·5
Hampstead - - -	1,485	1,272	9	—	128	13	63	5·1
Holborn - - -	5,187	4,042	6	—	554	39	546	11·3
Islington - - -	9,638	7,581	22	—	1,120	198	717	9·5
Kensington - - -	3,742	3,125	18	—	318	29	252	7·5
Lambeth - - -	8,954	6,844	29	—	887	128	1,066	13·3
Lewisham - - -	2,309	1,968	10	—	178	19	134	6·6
London, City of - -	758	612	2	—	74	9	61	9·2
Marylebone - - -	4,561	3,787	13	—	391	106	264	8·1
Mile End Old Town -	3,997	2,994	7	—	334	113	549	16·6
Olave, St. - - -	5,115	3,814	12	—	501	153	635	15·4
Paddington - - -	2,870	2,275	7	—	223	68	297	12·7
Pancras, St. - -	7,358	5,696	35	—	655	142	830	13·2
Poplar - - -	5,874	4,433	35	—	519	29	858	15·1
Saviour, St. - -	7,034	5,420	6	—	738	72	798	12·4
Shoreditch - - -	4,540	3,849	3	—	438	33	217	5·5
Stepney - - -	2,109	1,729	8	—	186	—	186	8·8
Strand - - -	585	392	1	—	97	—	95	16·2
Wandsworth and Clapham	9,297	7,224	54	—	831	251	937	12·8
Westminster - -	913	690	3	—	110	31	79	12·0
Whitechapel - -	2,635	2,344	3	—	215	2	71	2·8
Woolwich - - -	3,622	3,180	7	—	308	14	113	3·5
	132,273	103,930	427	—	12,604	1,970	13,342	11·6

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—	Returns, 1889.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Died unvaccinated.	Vaccination postponed.	Remaining.	Children not finally accounted for (including cases postponed), per cent. of births.
BEDFORD.								
Ampthill	424	373	—	—	38	5	8	3·1
Bedford	1,326	1,004	3	—	135	50	134	13·9
Biggleswade	790	624	1	—	70	10	85	12·0
Leighton Buzzard	589	494	4	—	49	4	38	7·1
Luton	1,420	298	—	—	209	16	897	64·3
Woburn	255	209	—	—	22	1	23	9·4
BERKS.								
Abingdon	562	497	—	—	43	2	20	3·9
Bradfield	513	479	—	—	22	2	10	2·3
Cookham	531	443	—	—	34	38	16	10·2
Easthamstead	391	359	—	—	19	—	13	3·3
Faringdon	388	338	—	—	26	12	12	6·2
Hungerford	492	455	1	—	27	4	5	1·8
Newbury	595	514	3	—	49	12	17	4·9
Reading	1,827	1,432	3	—	162	67	163	12·6
Wallingford	373	350	1	—	16	2	4	1·6
Wantage	486	435	—	—	42	6	3	1·9
Windsor	890	757	1	—	65	1	66	7·5
Wokingham	496	428	3	—	30	5	30	7·1
BUCKS.								
Amersham	595	545	1	—	34	2	13	2·5
Aylesbury	758	649	1	—	54	18	36	7·1
Buckingham	298	264	—	—	21	1	12	4·4
Eton	753	672	—	—	56	9	16	3·3
Newport Pagnell	750	660	—	—	56	6	28	4·5
Winslow	235	195	—	—	27	4	9	5·5
Wycombe	1,255	1,115	1	—	96	12	31	3·4
CAMBRIDGE.								
Cambridge	1,016	848	4	—	87	37	40	7·6
Caxton and Arrington	246	233	—	—	9	2	2	1·6
Chesterton	831	745	1	—	51	7	27	4·1
Ely	582	491	2	—	61	17	11	4·8
Linton	369	331	—	—	26	5	7	3·3
Newmarket	908	790	1	—	99	13	5	2·0
North Witchford	497	456	3	—	30	2	6	1·6
Whittlesey	184	170	—	—	10	—	4	2·2
Wisbech	931	730	—	—	80	5	116	13·0
CHESTER.								
Altrincham	1,689	1,496	6	—	132	24	31	3·3
Birkenhead	4,139	3,640	11	—	403	29	56	2·1
Chester	1,442	1,257	—	—	144	8	33	2·8
Congleton	1,123	971	—	—	125	14	13	2·4
Macclesfield	1,638	1,399	—	—	191	23	25	2·9
Nantwich	2,159	1,796	9	—	220	38	96	6·2
Northwich	1,751	1,566	—	—	165	9	11	1·1
Runcorn	1,400	1,216	—	—	148	9	27	2·6
Stockport	4,041	3,284	19	—	469	51	218	6·7
Tarvin	320	284	1	—	27	1	7	2·5
Wirral	991	841	5	—	69	17	59	7·7

—	Returns, 1889.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Died unvaccinated.	Vaccination postponed.	Remaining.	Children not finally accounted for (including cases postponed), per cent. of births.
CORNWALL.								
Austell, St.	892	778	—	—	79	20	15	3·9
Bodmin	512	456	1	—	36	8	11	3·7
Camelford	182	157	—	—	16	7	2	4·9
Columb, St., Major	407	361	—	—	27	8	11	4·7
Falmouth	631	308	1	—	76	5	241	39·0
Germans, St.	495	438	—	—	42	9	6	3·0
Helston	622	512	—	—	71	24	15	6·3
Launceston	407	381	3	—	17	3	3	1·5
Liskeard	716	619	1	—	66	9	21	4·2
Penzance	1,438	1,165	—	—	153	18	102	8·3
Redruth	1,560	1,136	—	—	238	62	124	11·9
Stratton	231	208	—	—	17	3	3	2·6
Truro	895	653	1	—	80	13	148	18·0
CUMBERLAND.								
Alston-with-Garrigill	65	59	—	—	1	2	3	7·7
Bootle	474	285	—	—	54	2	133	28·5
Brampton	258	206	—	—	22	19	11	11·6
Carlisle	1,587	1,387	1	—	137	42	20	3·9
Cockermouth	2,432	1,910	—	—	307	98	117	8·8
Longtown	197	172	1	—	16	7	1	4·1
Penrith	570	517	1	—	44	4	4	1·4
Whitehaven	2,007	1,734	—	—	181	24	68	4·6
Wigton	647	544	—	—	63	10	30	6·2
DERBY.								
Ashbourne	553	482	—	—	43	—	28	5·1
Bakewell	841	701	—	—	75	23	42	7·7
Belper	1,979	1,771	4	—	167	11	26	1·9
Chapel-en-le-Frith	622	527	2	—	61	13	19	5·1
Chesterfield	3,670	2,966	2	—	366	55	281	9·2
Derby	2,729	2,039	12	—	314	52	312	13·3
Glossop	773	618	4	—	91	6	54	7·8
Hayfield	337	290	—	—	27	3	17	5·9
Shardlow	1,836	1,571	1	—	143	19	102	6·6
DEVON.								
Axminster	514	450	—	—	49	9	6	2·9
Barnstaple	1,156	1,009	—	—	87	29	31	5·2
Bideford	613	555	—	—	44	12	2	2·3
Crediton	524	476	—	—	42	2	4	1·1
East Stonehouse	529	413	2	—	71	16	27	8·1
Exeter	1,038	799	—	—	129	52	58	10·6
Holsworthy	258	234	—	—	20	3	1	1·6
Honiton	547	482	—	—	35	18	12	5·5
Kingsbridge	461	419	—	—	34	7	1	1·7
Newton Abbot	1,844	1,660	2	—	149	10	23	1·8
Okehampton	459	418	—	—	23	4	14	3·9
Plymouth	2,503	1,917	5	1	319	44	217	10·4
Plympton St. Mary	681	578	1	—	45	6	51	8·4
Southmolton	441	382	—	—	38	10	11	4·8
Stoke Damerel	1,574	1,179	—	—	178	66	151	13·8
Tavistock	787	707	3	—	67	3	7	1·3
Thomas, St.	1,422	1,187	1	—	134	44	56	7·0
Tiverton	798	718	6	—	44	7	23	3·8
Torrington	393	356	—	—	30	4	3	1·8
Totnes	1,089	976	4	—	82	5	22	2·5

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	Returns, 1889.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Died unvaccinated.	Vaccination postponed.	Remaining.	Children not finally accounted for (including cases postponed), per cent. of births.
DORSET.								
Beaminster	312	267	—	—	29	7	9	5·1
Blandford	339	294	—	—	20	7	18	7·4
Bridport	385	337	1	—	34	7	6	3·4
Cerne	203	189	—	—	10	2	2	2·0
Dorchester	512	462	—	—	31	4	15	3·7
Poole	701	621	2	—	49	11	18	4·1
Shaftesbury	314	283	—	—	9	7	15	7·0
Sherborne	369	346	—	—	17	1	5	1·6
Sturminster	273	239	—	—	19	5	10	5·5
Wareham and Purbeck	500	467	—	—	29	—	4	0·8
Weymouth	814	583	—	—	85	22	124	17·9
Wimborne and Cranborne	515	447	3	—	20	11	25	7·0
DURHAM.								
Auckland	3,026	2,401	1	—	352	55	217	9·0
Chester-le-Street	1,766	1,451	2	—	196	32	85	6·6
Darlington	1,451	1,109	—	—	189	7	146	10·5
Durham	2,407	2,065	3	—	235	29	75	4·3
Easington	1,835	1,570	1	—	204	16	44	3·3
Gateshead	4,529	3,490	4	—	543	24	468	10·9
Hartlepool	2,410	1,872	—	—	267	37	234	11·2
Houghton-le-Spring	1,444	1,224	4	—	162	6	48	3·7
Lanchester	2,167	1,787	3	—	253	20	104	5·7
Sedgefield	661	575	—	—	65	8	13	3·2
South Shields	5,009	3,491	3	—	573	170	772	18·8
Stockton	2,087	1,618	2	—	218	53	196	11·9
Sunderland	5,895	4,860	6	—	677	53	299	6·0
Teesdale	594	498	—	—	46	21	29	8·4
Weardale	497	434	1	—	49	11	2	2·6
ESSEX.								
Billericay	502	431	2	—	27	8	34	8·4
Braintree	734	667	1	—	42	7	17	3·3
Chelmsford	935	808	—	—	72	15	40	5·9
Colchester	950	752	1	—	83	15	99	12·0
Dunmow	430	387	—	—	28	8	7	3·5
Epping	713	624	1	—	53	7	28	4·9
Halstead	474	417	—	—	35	13	9	4·6
Lexden and Winstree	645	587	—	—	42	9	7	2·5
Maldon	687	609	1	—	46	5	26	4·5
Ongar	294	255	—	—	15	6	18	8·2
Orsett	932	754	3	—	81	42	52	10·1
Rochford	880	744	3	—	91	25	17	4·8
Romford	1,612	1,257	1	—	126	18	210	14·1
Saffron Walden	490	438	—	—	28	1	23	4·9
Tendring	1,087	949	2	—	104	9	23	2·9
West Ham	11,801	9,331	49	—	959	293	1,169	12·4
GLOUCESTER.								
Barton Regis	5,704	4,786	26	—	568	81	243	5·7
Bristol	1,637	1,324	4	—	173	17	119	8·3
Cheltenham	1,278	894	—	—	131	54	199	19·8
Chipping Sodbury	467	413	—	—	33	5	16	4·5
Cirencester	530	441	1	—	39	14	35	9·2
Dursley	332	289	—	—	18	1	24	7·5
Gloucester	1,526	95	—	—	161	1	1,269	83·2
Newent	327	288	—	—	21	5	13	5·5
Northleach	230	185	—	—	23	3	19	9·6

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—	Returns, 1889.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Died unvaccinated.	Vaccination postponed.	Remaining.	Children not finally accounted for (including cases postponed), per cent. of births.
GLOUCESTER—*cont.*								
Stow-on-the-Wold	255	222	2	—	21	4	6	3·9
Stroud	1,108	945	2	—	97	16	48	5·8
Tetbury	158	129	—	—	14	9	6	9·5
Tewkesbury	389	310	1	—	31	7	40	12·1
Thornbury	496	456	—	—	25	6	9	3·0
Westbury-on-Severn	797	519	—	—	90	112	76	23·6
Wheatenhurst	188	136	—	—	9	31	12	22·9
Winchcomb	255	229	1	—	11	5	9	5·5
HEREFORD.								
Bromyard	301	260	—	—	21	8	12	6·6
Dore	191	163	—	—	15	10	3	6·8
Hereford	920	798	—	—	80	7	35	4·6
Kington	306	264	1	—	25	2	14	5·2
Ledbury	327	283	1	—	26	7	10	5·2
Leominster	342	302	—	—	29	1	10	3·2
Ross	412	349	2	—	44	3	14	4·1
Weobley	196	167	—	—	15	2	12	7·1
HERTS.								
Albans, St.	762	533	—	—	58	6	165	22·4
Barnet	1,196	836	1	—	118	34	207	20·2
Berkhampstead	430	366	1	—	51	2	10	2·8
Bishop's Stortford	565	516	1	—	34	5	9	2·5
Buntingford	152	130	—	—	6	1	15	10·5
Hatfield	203	185	—	—	10	3	5	3·9
Hemel Hempstead	450	385	—	—	42	6	17	15·1
Hertford	409	351	1	—	29	4	24	6·8
Hitchin	800	734	3	—	51	2	10	1·5
Royston	458	416	—	—	28	3	11	3·1
Ware	557	498	1	—	40	7	11	3·2
Watford	994	823	1	—	64	21	85	10·7
Welwyn	63	56	—	—	6	—	1	1·6
HUNTINGDON.								
Huntingdon	561	501	—	—	48	5	7	2·1
Ives, St.	423	374	—	—	31	7	11	4·3
Neots, St.	429	388	—	—	27	1	13	3·3
KENT (Extra-Metropolitan).								
Ashford, East	392	338	—	—	34	4	16	5·1
Ashford, West	556	457	1	—	48	20	30	9·0
Blean	578	505	1	—	45	7	20	4·7
Bridge	331	283	—	—	26	5	17	6·6
Bromley	1,863	1,528	7	—	235	47	46	5·0
Canterbury	524	459	2	—	45	1	17	3·4
Cranbrook	318	282	—	—	27	3	6	2·8
Dartford	1,970	1,624	2	—	133	64	147	10·7
Dover	1,106	878	1	—	85	32	110	12·8
Eastry	764	677	—	—	62	6	19	3·3
Elham	1,076	913	3	—	83	19	58	7·2
Faversham	820	740	7	—	55	1	17	2·2
Gravesend and Milton	647	502	2	—	51	5	87	14·2
Hollingbourn	374	340	—	—	21	3	10	3·5
Hoo	137	116	—	—	11	—	10	7·3
Maidstone	1,396	1,119	1	—	114	10	152	11·6

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KENT (Extra-Metropolitan)—*cont.*								
Malling	904	779	—	—	68	9	48	6·3
Medway	2,259	1,874	3	—	182	105	95	8·9
Milton	917	794	—	—	84	20	19	4·3
Romney Marsh	221	205	—	—	11	2	3	2·3
Sevenoaks	793	705	—	—	48	9	31	5·0
Sheppey	543	497	—	—	34	2	10	2·2
Strood	1,240	1,069	—	—	116	9	46	4·4
Tenterden	268	242	—	—	20	—	6	2·2
Thanet, Isle of	1,385	1,193	4	—	114	25	49	5·3
Tonbridge	1,462	1,104	7	—	120	32	199	15·8
LANCASTER.								
Ashton-under-Lyne	5,122	3,820	14	—	693	57	538	11·6
Barrow-in-Furness	1,774	1,580	2	—	146	16	30	2·6
Barton-upon-Irwell	2,648	2,151	8	—	281	61	147	7·8
Blackburn	6,845	5,813	16	—	715	51	250	4·4
Bolton	7,311	6,565	17	—	606	19	104	1·7
Burnley	5,787	3,462	13	—	848	92	1,372	25·3
Bury	4,112	3,594	12	—	377	29	100	3·1
Chorley	1,789	1,511	3	—	197	14	64	4·4
Chorlton	9,184	7,325	15	—	1,111	213	520	8·0
Clitheroe	641	507	—	—	76	24	34	9·0
Fylde, The	1,518	1,275	4	—	176	24	39	4·2
Garstang	301	269	—	—	22	3	7	3·3
Haslingden	2,972	2,466	—	—	294	32	180	7·1
Lancaster	1,497	1,283	1	—	160	18	35	3·5
Leigh	2,554	2,192	—	—	230	13	119	5·2
Liverpool	5,267	4,326	15	—	698	8	220	4·3
Lunesdale	207	175	—	—	24	1	7	3·9
Manchester	5,207	4,328	6	—	642	65	166	4·4
Oldham	6,176	892	8	—	889	29	4,358	71·0
Ormskirk	2,725	2,280	11	—	292	46	96	5·2
Prescot	5,171	4,207	5	—	636	112	211	6·2
Preston	4,977	3,668	15	—	753	31	510	10·9
Prestwich	4,902	3,906	10	—	463	145	378	10·7
Rochdale	3,120	2,651	12	—	310	37	110	4·7
Salford	7,239	5,499	20	—	928	186	606	11·0
Todmorden	1,012	852	1	—	89	—	70	6·9
Toxteth Park	4,159	3,113	20	—	477	115	434	13·2
Ulverston	1,342	1,138	1	—	134	41	28	5·1
Warrington	3,055	2,573	4	—	296	28	154	6·0
West Derby	14,731	12,404	31	—	1,470	153	673	5·6
Wigan	6,425	5,408	10	—	720	98	189	4·3
LEICESTER.								
Ashby-de-la-Zouch	1,217	957	2	—	142	10	106	9·5
Barrow-on-Soar	1,118	366	1	—	162	10	579	52·7
Billesdon	387	218	—	—	43	—	126	32·6
Blaby	1,098	677	5	—	149	20	247	24·3
Hinckley	723	537	—	—	87	2	97	13·7
Leicester	4,786	127	4	—	834	—	3,821	79·8
Loughborough	1,016	650	—	—	132	4	230	23·0
Lutterworth	290	253	—	—	24	5	8	4·5
Market Bosworth	492	414	1	—	37	13	27	8·1
Market Harborough	456	396	—	—	38	2	20	4·8
Melton Mowbray	608	517	—	—	64	4	23	4·4

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LINCOLN.								
Boston - - -	1,120	932	—	—	116	18	54	6·4
Bourn - - -	547	452	1	—	57	19	18	6·8
Caistor - - -	449	374	1	—	50	12	12	5·3
Gainsborough - -	1,041	876	2	—	108	9	46	5·3
Glanford Brigg - -	1,246	1,087	1	—	122	3	33	2·8
Grantham - - -	983	852	1	—	99	6	25	3·2
Grimsby - - -	2,050	1,598	—	—	269	65	118	8·9
Holbeach - - -	509	442	—	—	46	3	18	4·1
Horncastle - - -	547	468	—	—	49	6	24	5·5
Lincoln - - -	1,917	1,510	2	—	262	46	97	7·5
Louth - - -	865	711	3	—	92	19	40	6·8
Sleaford - - -	640	548	—	—	55	7	30	5·8
Spalding - - -	611	517	2	—	61	9	22	5·1
Spilsby - - -	703	610	6	—	57	9	21	4·3
Stamford - - -	470	396	—	—	40	14	20	7·2
MIDDLESEX (Extra-Metropolitan).								
Brentford - - -	3,858	3,192	17	—	325	26	298	8·4
Edmonton - - -	7,221	5,828	33	—	557	107	696	11·1
Hendon - - -	2,953	2,349	14	—	258	40	292	11·2
Staines - - -	762	612	3	—	67	7	73	10·5
Uxbridge - - -	856	740	5	—	74	7	30	4·3
MONMOUTH.								
Abergavenny - -	709	624	—	—	61	18	6	3·4
Bedwellty - - -	2,134	1,744	—	—	244	55	91	6·8
Chepstow - - -	583	498	—	—	51	11	23	5·8
Monmouth - - -	834	724	2	—	59	14	35	5·9
Newport - - -	3,431	2,883	3	—	358	48	139	5·5
Pontypool - - -	1,342	1,114	—	—	148	21	59	6·0
NORFOLK.								
Aylsham - - -	502	443	—	—	42	7	10	3·4
Blofield - - -	367	335	—	—	22	3	7	2·7
Depwade - - -	662	563	—	—	54	15	30	6·8
Docking - - -	432	381	2	—	36	4	9	3·0
Downham - - -	540	463	2	—	57	8	10	3·3
Erpingham - - -	494	418	—	—	44	6	26	6·5
Faith, St. - - -	316	265	—	—	23	8	20	8·9
Fleggs, East and West -	343	303	—	—	35	1	4	1·5
Forehoe - - -	342	296	—	—	25	4	17	6·1
Freebridge Lynn - -	366	309	2	—	32	7	16	6·3
Guiltcross - - -	280	246	—	—	20	3	11	5·0
Henstead - - -	291	229	1	—	21	3	37	13·7
King's Lynn - -	550	395	1	—	62	2	90	1·7
Loddon and Clavering -	363	313	—	—	35	2	13	4·1
Mitford and Launditch -	785	676	—	—	79	7	23	3·8
Norwich - - -	3,208	2,437	10	—	385	32	344	11·7
Smallburgh - - -	537	468	—	—	47	4	18	4·1
Swaffham - - -	342	282	1	—	31	4	24	8·2
Thetford - - -	455	423	1	—	24	3	4	1·5
Walsingham - - -	586	514	—	—	48	8	16	4·1
Wayland - -	288	254	—	—	23	3	8	3·8
Yarmouth, Great -	1,172	900	2	—	132	29	109	11·8

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NORTHAMPTON.								
Brackley	302	240	—	—	21	5	36	13·6
Brixworth	331	276	1	—	23	7	24	9·4
Daventry	478	428	—	—	33	3	14	3·6
Hardingstone	299	245	—	—	25	11	18	9·7
Kettering	1,122	496	—	—	106	19	501	46·3
Northampton	2,439	546	—	—	342	52	1,499	63·6
Oundle	379	346	—	—	21	6	6	3·2
Peterborough	1,331	1,156	—	—	113	9	53	4·7
Potterspury	329	263	1	—	38	12	15	8·2
Thrapston	421	230	—	—	37	—	154	36·6
Towcester	347	287	—	—	31	19	10	8·3
Wellingborough	1,399	772	1	—	177	40	409	32·1
NORTHUMBERLAND.								
Alnwick	595	499	—	—	53	17	26	7·2
Belford	142	133	—	—	8	—	1	0·7
Bellingham	122	110	—	—	8	—	4	3·3
Berwick-upon-Tweed	521	455	1	—	46	9	10	3·6
Castle Ward	690	590	1	—	71	4	24	4·1
Glendale	215	198	—	—	10	3	4	3·3
Haltwhistle	202	162	—	—	27	7	6	6·4
Hexham	860	738	—	—	80	9	33	4·9
Morpeth	1,342	1,086	—	—	232	7	17	1·8
Newcastle-on-Tyne	6,618	5,440	12	—	771	164	231	6·0
Rothbury	149	136	—	—	13	—	—	0·0
Tynemouth	4,285	3,394	8	—	535	143	205	8·1
NOTTINGHAM.								
Basford	5,596	4,562	10	—	637	76	311	6·9
Bingham	356	297	1	—	26	13	19	9·0
East Retford	648	582	2	—	49	2	13	2·3
Mansfield	1,928	1,537	—	—	257	23	111	7·0
Newark	863	750	1	—	80	18	14	3·7
Nottingham	5,398	3,672	13	—	674	147	892	19·2
Southwell	493	421	4	—	47	4	17	4·3
Worksop	1,096	967	1	—	96	14	18	2·9
OXFORD.								
Banbury	814	365	—	—	73	24	352	46·2
Bicester	377	335	—	—	26	6	10	4·2
Chipping Norton	545	452	—	—	45	17	31	8·8
Headington	1,006	887	—	—	105	4	10	1·4
Henley	644	537	1	—	52	29	25	8·4
Oxford	683	570	2	—	80	10	21	4·5
Thame	399	348	1	—	30	9	11	5·0
Witney	660	547	—	—	31	10	12	3·7
Woodstock	382	317	3	—	44	5	13	4·7
RUTLAND.								
Oakham	276	245	—	—	24	2	5	2·5
Uppingham	290	251	1	—	25	2	11	4·5

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SALOP.								
Atcham	1,295	1,049	—	—	145	44	57	7·8
Bridgnorth	401	347	—	—	24	6	24	7·5
Church Stretton	139	123	—	—	13	1	2	2·2
Cleobury Mortimer	244	222	—	—	15	3	4	2·9
Clun	255	211	—	—	25	1	18	7·5
Drayton	365	341	1	—	18	2	3	1·4
Ellesmere	353	307	1	—	38	3	4	2·0
Ludlow	498	418	1	—	50	14	15	5·8
Madeley	653	595	—	—	46	1	11	1·8
Newport	432	388	—	—	28	5	11	3·7
Oswestry	850	765	1	—	66	4	14	2·1
Shifnal	352	304	1	—	31	5	11	4·5
Wellington	737	658	—	—	61	2	16	2·4
Wem	274	235	1	—	27	2	9	4·0
Whitchurch	336	305	—	—	26	1	4	1·5
SOMERSET.								
Axbridge	1,096	884	4	—	96	15	97	10·2
Bath	1,805	1,183	2	—	187	119	314	24·0
Bedminster	2,498	1,970	11	—	249	113	155	10·7
Bridgwater	1,021	886	—	—	55	35	45	7·8
Chard	690	615	—	—	38	16	21	5·4
Clutton	821	717	—	—	61	6	37	5·2
Dulverton	139	127	—	—	8	—	4	2·9
Frome	621	552	3	—	45	1	20	3·4
Keynsham	936	770	4	—	80	34	48	8·8
Langport	376	313	—	—	46	6	11	4·5
Shepton Mallet	437	362	—	—	41	—	34	7·8
Taunton	1,046	872	4	—	85	21	64	8·1
Wellington	485	414	4	—	34	12	21	6·8
Wells	715	624	1	—	53	6	31	5·2
Williton	443	398	—	—	35	5	5	2·3
Wincanton	554	487	—	—	39	9	19	5·1
Yeovil	807	654	—	—	88	29	36	8·1
SOUTHAMPTON.								
Alresford	181	162	—	—	15	2	2	2·2
Alton	425	398	—	—	17	—	10	2·4
Alverstoke	866	775	2	—	77	1	11	1·4
Andover	425	348	—	—	31	7	39	10·8
Basingstoke	530	364	—	—	47	1	118	22·5
Catherington	81	73	—	—	2	1	5	7·4
Christchurch	1,175	930	4	—	99	—	142	12·1
Droxford	330	287	—	—	23	8	12	6·1
Fareham	559	500	—	—	38	2	19	3·8
Fordingbridge	179	159	1	—	14	—	5	2·8
Hartley Wintney	661	561	2	—	44	13	41	8·2
Havant	255	226	—	—	18	4	7	4·3
Hursley	75	68	1	—	3	3	—	4·0
Kingsclere	246	223	—	—	20	2	1	1·2
Lymington	356	318	—	—	16	1	21	6·2
New Forest	356	315	—	—	16	5	20	7·0
Petersfield	313	271	—	—	21	7	14	6·7
Portsea Island	4,952	4,383	9	—	438	21	101	2·5
Ringwood	149	141	1	—	7	—	—	0·0
Romsey	319	284	—	—	18	7	10	5·3
Southampton	1,660	1,341	1	—	144	50	124	10·5
South Stoneham	1,371	1,191	—	—	70	30	80	8·0
Stockbridge	182	150	—	—	17	4	11	8·2
Whitchurch	183	157	—	—	13	8	5	7·1
Wight, Isle of	1,939	1,624	4	—	142	48	121	8·7
Winchester, New	832	741	—	—	62	9	20	3·5

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STAFFORD.								
Burton-upon-Trent	2,830	2,217	2	—	288	29	294	11·4
Cannock	1,319	1,131	2	—	129	2	55	4·2
Cheadle	774	653	—	—	76	7	38	5·8
Leek	1,128	976	—	—	104	18	30	4·3
Lichfield	1,338	1,204	7	—	110	5	12	1·3
Newcastle-under-Lyme	1,290	1,132	2	—	113	4	39	3·3
Seisdon	462	409	—	—	34	1	18	4·1
Stafford	871	723	2	—	99	9	38	5·4
Stoke-upon-Trent	4,469	3,616	2	—	572	59	220	6·2
Stone	964	833	1	—	94	11	25	3·7
Tamworth	732	624	—	—	75	11	22	4·5
Uttoxeter	409	382	1	—	23	1	2	0·7
Walsall	3,604	2,665	3	1	492	73	370	12·0
West Bromwich	4,726	4,046	13	—	563	37	67	2·2
Wolstanton and Burslem	3,001	2,521	1	—	392	7	80	2·9
Wolverhampton	4,732	3,696	8	—	607	67	354	8·9
SUFFOLK.								
Blything	770	647	—	—	59	9	55	8·3
Bosmere and Claydon	460	385	4	—	33	9	29	8·3
Bury St. Edmunds	480	428	—	—	37	1	14	3·1
Cosford	518	461	—	—	40	6	11	3·3
Hartismere	445	397	—	—	29	8	11	4·3
Hoxne	345	299	—	—	27	5	14	5·5
Ipswich	1,686	1,226	6	—	156	61	237	17·7
Mildenhall	243	220	—	—	20	—	3	1·2
Mutford and Lothingland	1,664	1,488	4	—	127	22	23	2·7
Plomesgate	560	501	1	—	35	3	20	4·1
Risbridge	519	459	1	—	47	3	9	2·3
Samford	355	320	—	—	23	3	9	3·4
Stow	588	533	—	—	43	4	8	2·0
Sudbury	807	692	3	—	56	26	30	6·9
Thingoe	459	418	—	—	29	3	9	2·6
Wangford	451	412	—	—	30	3	6	2·0
Woodbridge	639	540	1	—	59	16	32	7·5
SURREY (Extra-Metropolitan).								
Chertsey	857	686	1	—	52	51	67	13·8
Croydon	3,985	2,800	6	—	328	77	774	21·4
Dorking	401	338	2	—	22	3	36	9·7
Epsom	1,203	967	5	—	96	83	52	11·2
Farnham	1,449	1,251	8	—	116	13	61	5·1
Godstone	425	358	1	—	27	—	39	9·2
Guildford	1,387	1,223	3	—	78	19	64	6·0
Hambledon	498	441	—	—	37	3	17	4·0
Kingston	2,769	2,328	7	—	283	97	54	5·5
Reigate	906	785	3	—	67	27	24	5·6
Richmond	1,072	940	—	—	90	2	40	3·9
SUSSEX.								
Battle	493	400	—	—	50	8	35	8·7
Brighton	2,654	2,212	11	—	263	46	122	6·3
Chailey	250	212	—	—	16	9	13	8·8
Chichester	206	188	2	—	10	2	4	2·9
Cuckfield	580	492	—	—	48	15	25	6·9
Eastbourne	902	344	—	—	108	10	536	54·4
East Grinstead	507	443	1	—	21	15	27	8·3
East Preston	784	700	—	—	52	14	18	4·1

—	Returns, 1889.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Died unvaccinated.	Vaccination postponed.	Remaining.	Children not finally accounted for (including cases postponed), per cent. of births.
SUSSEX—*cont.*								
Hailsham	443	364	—	—	37	6	36	9·5
Hastings	1,431	1,157	2	—	125	43	104	10·3
Horsham	655	583	1	—	35	3	33	5·5
Lewes	310	202	—	—	26	—	82	26·5
Midhurst	364	341	—	—	16	3	4	1·9
Newhaven	267	206	—	—	30	9	22	11·6
Petworth	263	232	—	—	25	4	2	2·3
Rye	318	292	—	—	17	1	8	2·8
Steyning	1,419	1,241	5	—	93	33	47	5·6
Thakeham	231	210	—	—	17	2	2	1·7
Ticehurst	445	377	—	—	40	2	26	6·3
Uckfield	601	472	1	—	41	21	66	14·5
Westbourne	203	189	—	—	8	1	5	3·0
West Firle	73	54	—	—	2	14	3	23·3
Westhampnett	539	493	—	—	28	5	13	3·3
WARWICK.								
Alcester	603	530	—	—	46	1	26	4·5
Aston	8,477	6,788	23	—	897	100	669	9·1
Atherstone	559	487	2	—	40	12	18	5·4
Birmingham	8,087	6,743	19	—	858	41	426	5·8
Coventry	1,512	1,274	1	—	187	28	22	3·3
Foleshill	610	524	—	—	55	—	31	5·1
Meriden	259	228	1	—	15	2	13	5·8
Nuneaton	598	486	—	—	73	5	34	6·5
Rugby	767	695	2	—	54	4	12	2·1
Solihull	731	614	1	—	54	16	46	8·5
Southam	293	250	1	—	28	1	13	4·8
Stratford-on-Avon	585	508	—	—	50	6	21	4·6
Warwick	1,322	1,134	5	—	122	10	51	4·6
WESTMORLAND.								
East Ward	355	322	—	—	26	3	4	2·0
Kendal	1,281	1,119	—	—	104	18	40	4·5
West Ward	202	176	1	—	11	1	13	6·9
WILTS.								
Alderbury	739	645	—	—	48	12	34	6·2
Amesbury	173	161	—	—	9	—	3	1·7
Bradford	297	259	—	—	30	1	7	2·7
Calne	205	173	—	—	9	15	8	11·2
Chippenham	614	550	—	—	37	16	11	4·4
Cricklade and Wootton Bassett.	367	324	—	—	29	—	14	3·8
Devizes	581	511	1	—	33	17	19	6·2
Highworth and Swindon	1,544	1,245	2	—	141	34	122	10·1
Malmesbury	373	323	—	—	21	12	17	7·8
Marlborough	236	215	—	—	17	—	4	1·7
Melksham	502	451	1	—	33	6	11	3·4
Mere	190	175	—	—	7	4	4	4·2
Pewsey	336	296	—	—	32	1	7	2·4
Tisbury	262	223	—	—	22	11	6	6·5
Warminster	320	279	—	—	10	3	28	9·7
Westbury and Whorwellsdown.	284	262	1	—	20	—	1	0·4
Wilton	272	248	—	—	12	5	7	4·4

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Digest of Vaccination Officers' Returns, 1889.

	Returns, 1889.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Died unvaccinated.	Vaccination postponed.	Remaining.	Children not finally accounted for (including cases postponed), per cent. of births.
WORCESTER.								
Bromsgrove	1,043	896	1	—	109	18	19	3·5
Droitwich	587	528	—	—	42	4	13	2·9
Dudley	5,318	4,632	10	—	565	30	81	2·1
Evesham	478	430	—	—	28	4	16	4·2
Kidderminster	1,119	993	2	—	96	4	24	2·5
King's Norton	3,302	2,827	12	—	308	30	125	4·7
Martley	423	377	1	—	28	—	17	4·0
Pershore	324	301	—	—	18	—	5	1·5
Shipston-on-Stour	476	435	1	—	22	2	16	3·8
Stourbridge	2,808	2,504	1	—	268	12	23	1·2
Tenbury	191	164	—	—	17	1	9	5·2
Upton-on-Severn	559	464	4	—	58	5	28	5·9
Worcester	1,330	1,027	4	—	162	25	112	10·3
YORK, East Riding.								
Beverley	718	610	1	—	66	9	32	5·7
Bridlington	476	385	—	—	55	2	34	7·6
Driffield	591	501	—	—	68	4	18	3·7
Howden	342	283	—	—	41	2	16	5·3
Kingston-upon-Hull	2,542	1,934	16	—	328	14	250	10·4
Patrington	221	191	—	—	22	—	8	3·6
Pocklington	421	343	1	—	47	10	20	7·1
Sculcoates	4,616	3,784	20	—	531	31	250	6·1
Skirlaugh	259	225	—	—	25	5	4	3·5
York	2,429	2,006	9	—	273	26	115	5·8
YORK, North Riding.								
Aysgarth	127	113	1	—	10	3	—	2·4
Bedale	208	176	—	—	23	3	6	4·3
Easingwold	237	205	—	—	22	1	9	4·2
Guisborough	1,204	1,047	1	—	104	21	31	4·3
Helmsley	149	127	—	—	9	10	3	8·7
Kirkby Moorside	133	120	—	—	7	—	6	4·5
Leyburn	179	159	—	—	15	—	5	2·8
Malton	614	464	1	—	87	22	40	10·1
Middlesbrough	4,285	3,612	2	—	502	83	86	3·9
Northallerton	330	284	1	—	39	3	3	1·8
Pickering	338	264	—	—	39	3	32	10·4
Reeth	91	74	—	—	7	2	8	11·0
Richmond	306	240	1	—	30	7	28	11·4
Scarborough	1,205	808	2	—	150	57	188	20·3
Stokesley	302	269	—	—	20	5	8	4·3
Thirsk	337	292	1	—	30	4	10	4·2
Whitby	743	633	1	—	70	22	17	5·2
YORK, West Riding.								
Barnsley	3,523	2,752	1	—	348	42	380	12·0
Bierley, North	3,681	2,773	7	—	471	54	376	11·7
Bradford	5,910	3,859	12	—	821	19	1,199	20·6
Bramley	2,051	1,630	4	—	263	17	137	7·5
Dewsbury	4,660	2,281	3	—	637	69	1,670	37·3
Doncaster	1,993	1,638	8	—	215	90	42	6·6
Ecclesall Bierlow	4,041	3,402	20	—	456	27	136	4·0
Goole	905	764	3	—	91	8	39	5·2
Halifax	4,896	1,284	7	—	667	64	2,874	60·0

	Returns, 1889.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Died unvaccinated.	Vaccination postponed.	Remaining.	Children not finally accounted for (including cases postponed), per cent. of births.
YORK, West Riding—*cont.*								
Hemsworth	506	420	—	—	52	2	32	6·7
Holbeck	857	724	—	—	95	19	19	4·4
Huddersfield	4,407	3,891	12	—	408	22	74	2·2
Hunslet	2,461	2,079	5	—	281	22	74	3·9
Keighley	1,902	90	3	—	267	—	1,542	81·1
Knaresborough	682	535	1	—	69	23	54	11·3
Leeds	6,969	5,819	11	—	739	51	349	5·7
Ouseburn, Great	373	329	2	—	32	—	10	2·7
Pateley Bridge	233	215	—	—	14	2	2	1·7
Penistone	544	474	—	—	53	8	9	3·1
Pontefract	2,114	1,741	4	—	260	21	88	5·2
Ripon	457	378	—	—	32	21	26	10·3
Rotherham	3,245	2,700	9	—	360	29	147	5·4
Saddleworth	604	459	4	—	55	4	82	14·2
Sedbergh	112	96	—	—	12	2	2	3·6
Selby	490	443	—	—	35	4	8	2·4
Settle	377	330	—	—	35	4	8	3·2
Sheffield	7,473	6,203	20	—	866	22	362	5·1
Skipton	1,148	858	—	—	132	32	126	13·8
Tadcaster	832	697	—	—	98	8	29	4·4
Thorne	477	385	—	—	50	11	31	8·8
Wakefield	3,362	2,835	2	—	353	25	147	5·1
Wetherby	366	310	1	—	29	8	18	7·1
Wharfedale	1,382	1,001	2	—	154	51	174	16·3
Wortley	1,244	1,026	2	—	148	9	59	5·5
ANGLESEY.								
Anglesey	355	303	—	—	47	1	4	1·4
Holyhead	548	484	—	—	38	7	19	4·7
BRECKNOCK.								
Brecknock	418	359	2	—	47	5	5	2·4
Builth	222	188	—	—	31	1	2	1·4
Crickhowell	609	491	1	—	52	18	47	10·7
Hay	268	228	—	—	31	2	7	3·4
CARDIGAN.								
Aberayron	286	253	—	—	18	6	9	5·2
Aberystwith	482	434	—	—	35	2	11	2·7
Cardigan	438	383	—	—	38	5	12	3·9
Lampeter	261	229	—	—	27	3	2	1·9
Tregaron	218	185	—	—	19	3	11	6·4
CARMARTHEN.								
Carmarthen	940	849	—	—	72	8	11	2·0
Llanelly	1,612	1,428	—	—	153	18	13	1·9
Llandilofawr	570	508	—	—	49	2	11	2·3
Llandovery	322	274	—	—	41	4	3	2·2
Newcastle-in-Emlyn	532	486	—	—	42	1	3	0·8

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Digest of Vaccination Officers' Returns, 1889.

	Returns, 1889.							
	Births.	Successfully Vaccinated.	Insusceptible of Vaccination.	Had Small-pox.	Died unvaccinated.	Vaccination postponed.	Remaining.	Children not finally accounted for (including cases postponed), per cent. of births.
CARNARVON.								
Bangor and Beaumaris	917	806	—	—	75	23	13	3·9
Carnarvon	1,070	882	—	—	99	13	76	8·3
Conway	547	471	—	—	52	14	10	4·4
Pwllheli	548	479	—	—	44	14	11	4·6
DENBIGH.								
Llanrwst	306	252	—	—	34	12	8	6·5
Ruthin	308	273	1	—	31	1	2	1·0
Wrexham	1,889	1,591	6	—	206	53	33	4·6
FLINT.								
Asaph, St.	694	617	2	—	55	2	18	2·9
Hawarden	462	392	—	—	39	12	19	6·7
Holywell	1,168	970	1	—	115	27	55	7·0
GLAMORGAN.								
Bridgend and Cowbridge	1,527	1,313	1	—	173	17	23	2·6
Cardiff	5,653	4,668	9	—	595	20	361	6·7
Gower	320	278	—	—	28	10	4	4·4
Merthyr Tydfil	3,727	3,194	3	—	397	91	42	3·6
Neath	1,824	1,629	2	—	152	4	37	2·2
Pontardawe	660	585	—	—	57	13	5	2·7
Pontypridd	5,003	4,145	9	—	616	74	159	4·7
Swansea	3,901	3,460	3	—	337	25	76	2·6
MERIONETH.								
Bala	126	102	—	—	13	8	3	8·7
Corwen	439	375	1	—	42	15	6	4·8
Dolgelley	365	327	—	—	22	9	7	4·4
Festiniog	854	722	—	—	85	32	15	5·5
MONTGOMERY.								
Llanfyllin	521	446	—	—	52	11	12	4·4
Machynlleth	267	247	—	—	12	5	3	3·0
Forden	475	403	—	—	48	9	15	5·1
Newtown and Llanidloes	589	518	—	—	49	2	20	3·7
PEMBROKE.								
Haverfordwest	950	791	—	—	104	24	31	5·8
Narberth	467	414	—	—	38	—	15	3·2
Pembroke	972	833	—	—	85	23	31	5·6
RADNOR.								
Knighton	304	230	—	—	33	20	21	13·5
Rhayader	167	151	—	—	9	—	7	4·2

No. 2.

List (alphabetically arranged) of 266 Unions inspected during the Year 1891, with reference to the Proceedings under the Vaccination Acts, 1867 and 1871, and an Account of the Awards certified by the Board as payable to the respective Public Vaccinators out of County Funds.

UNION.	No. of Vaccination Districts in the Union.	No. of Public Vaccinators recommended for Award.	Range of Awards in each Union. Minimum.	Range of Awards in each Union. Maximum.	Total Sum awarded in each Union.	Medical Inspector.
			£ s. d.	£ s. d.	£ s. d.	
Abingdon	6	2	11 19 0	20 8 0	32 7 0	Mr. Sweeting.
Albans, St.	4	3	7 18 0	20 3 0	44 11	Dr. BruceLow.
Alcester	5	4	4 3 0	9 10 0	24 2 0	„ Parsons.
Alnwick	7	7	0 16 0	7 19 0	23 7 0	Mr. Thompson.
Anglesey	3	3	5 17 0	12 6 0	26 0 0	Dr. Parsons.
Asaph, St.	5	4	6 9 0	14 0 0	40 7 0	Do.
Ashbourne	6	6	1 11 0	18 16 0	43 17 0	„ BruceLow.
Ashford, East	6	4	2 5 0	8 3 0	21 15 0	Mr. Sweeting.
Ashford, West	4	4	2 6 0	15 3 0	32 12 0	Do.
Aston	7	7	7 7 0	80 14 0	251 19 0	Dr. Parsons.
Atherstone	2	2	9 1 0	28 10 0	37 11 0	Do.
Auckland	9	6	10 2 0	37 4 0	168 15 0	„ Copeman.
Aysgarth	2	1	—	—	4 11 0	„ Barry.
Bakewell	8	7	1 4 0	15 7 0	53 8 0	Dr. BruceLow.
Bala	1	—	—	—	—	„ Parsons.
Bangor and Beaumaris	6	3	8 10 0	14 18 0	36 2 0	Do.
Barnet	5	5	4 12 0	15 11 0	54 6 0	„ BruceLow.
Barnstaple	10	7	0 12 0	26 3 0	63 6 0	Do.
Barrow-in-Furness	1	1	—	—	160 16 0	Mr. Thompson.
Barton Regis	6	4	7 15 0	38 8 0	71 13 0	Dr. Blaxall.
Bedale	4	3	2 17 0	6 7 0	13 8 0	„ Barry.
Belford	2	1	—	—	8 10 0	Mr. Thompson.
Bellingham	6	2	1 8 0	2 14 0	4 2 0	Do.
Belper	9	5	3 7 0	42 12 0	108 7 0	Dr. BruceLow.
Berkhampstead	3	3	7 1 0	21 9 0	38 10 0	Do.
Berwick-on-Tweed	3	—	—	—	—	Mr. Thompson.

App. A. No. 2.

Inspection of Public Vaccination.

UNION.	No. of Vaccination Districts in the Union.	No. of Public Vaccinators recommended for Award.	Range of Awards in each Union. Minimum.	Range of Awards in each Union. Maximum.	Total Sum awarded in each Union.	Medical Inspector.
			£ s. d.	£ s. d.	£ s. d.	
Beverley - - -	5	3	5 10 0	42 14 0	56 7 0	Dr. Parsons.
Bideford - - -	6	4	4 14 0	17 9 0	37 15 0	„ BruceLow.
Birmingham - -	1	1	—	—	255 13 0	„ Airy.
Bishops Stortford -	7	4	1 19 0	13 8 0	25 7 0	„ BruceLow.
Blackburn - -	9	6	14 7 0	68 4 0	211 14 0	Mr. Thompson.
Blean - - -	4	3	4 16 0	12 16 0	28 17 0	„ Sweeting.
Blything - - -	8	6	5 2 0	12 3 0	61 14 0	Dr. Airy.
Bolton - - -	9	9	4 11 0	133 15 0	363 11 0	Mr. Thompson.
Bootle - - -	3	3	3 15 0	12 10 0	21 7 0	Do.
Bosmere and Claydon -	3	3	8 19 0	19 7 0	43 10 0	Dr. Airy.
Brackley - - -	4	4	3 11 0	6 15 0	19 1 0	„ Bruce Low.
Bradfield - - -	5	3	6 14 0	10 15 0	27 19 0	Mr. Sweeting.
Bradford (Yorks) -	4	3	29 3 0	58 10 0	132 7 0	Dr. Barry.
Bramley - - -	4	3	4 11 0	32 17 0	52 11 0	Mr. Sweeting.
Bridge - - -	5	1	—	—	3 5 0	Do.
Bridlington - -	4	2	3 14 0	11 13 0	15 7 0	Dr. Parsons.
Bristol - - -	1	1	—	—	30 9 0	„ Airy.
Brixworth - -	5	4	2 4 0	8 9 0	23 2 0	„ BruceLow.
Buntingford - -	2	1	—	—	5 0 0	Do.
Burnley - - -	7	2	6 6 0	12 18 0	19 4 0	Mr. Thompson.
Bury - - -	6	1	—	—	66 8 0	Do.
Bury St. Edmunds -	1	1	—	—	29 4 0	Dr. Airy.
Calne - - -	1	1	—	—	16 16 0	Dr. Ballard.
Canterbury - -	1	—	—	—	—	Mr. Sweeting.
Carlisle - - -	5	4	2 2 0	70 14 0	80 7 0	„ Thompson.
Carnarvon - - -	4	2	5 6 0	22 7 0	27 13 0	Dr. Parsons.
Castle Ward - -	6	3	2 10 0	34 6 0	42 9 0	Mr. Thompson.
Chapel-en-le-Frith -	3	3	3 19 0	21 1 0	41 15 0	Dr. BruceLow.
Chelsea - - -	2	2	11 16 0	60 2 0	71 18 0	„ Airy.
Cheltenham - -	3	—	—	—	—	„ Blaxall.
Chertsey - - -	5	4	5 18 0	21 3 0	51 13 0	Mr. Sweeting.
Chesterfield - -	11	11	7 10 0	41 8 0	249 1 0	Dr. BruceLow.
Chester-le-Street -	4	3	16 11 0	35 15 0	85 10 0	„ Copeman.
Chipping Sodbury -	5	2	3 11 0	5 0 0	8 11 0	„ Blaxall.
Chorley - - -	5	2	21 6 0	22 2 0	43 8 0	Mr. Thompson.

UNION.	No. of Vaccination Districts in the Union.	No. of Public Vaccinators recommended for Award.	Range of Awards in each Union. Minimum.	Range of Awards in each Union. Maximum.	Total Sum awarded in each Union.	Medical Inspector.
			£ s. d.	£ s. d.	£ s. d.	
Cirencester - -	5	3	5 15 0	11 18 0	25 8 0	Dr. Blaxall.
Clitheroe - - -	5	4	6 16 0	19 17 0	42 12 0	Mr. Thompson.
Conway - - -	3	2	9 17 0	13 11 0	23 8 0	Dr. Parsons.
Cookham - - -	3	1	—	—	3 10 0	Mr. Sweeting.
Corwen - - -	3	2	4 13 0	17 7 0	22 0 0	Dr. Parsons.
Cosford - - -	5	4	7 17 0	12 16 0	41 3 0	„ Airy.
Cranbrook - -	6	3	2 8 0	6 13 0	11 17 0	Mr. Sweeting.
Crediton - - -	11	6	1 7 0	11 19 0	30 4 0	Dr. BruceLow.
Croydon - - -	6	5	9 8 0	82 11 0	165 15 9	Mr. Sweeting.
Daventry - - -	6	6	2 4 0	9 12 0	32 6 0	Dr. BruceLow
Derby - - -	2	2	39 12 0	68 1 0	107 13 0	Do.
Dewsbury - - -	12	10	4 15 0	33 11 0	194 3 0	Do.
Dolgelley - - -	5	4	2 19 0	9 3 0	21 3 0	„ Parsons.
Doncaster - - -	7	5	3 16 0	39 3 0	63 14 0	„ BruceLow.
Dorking - - -	4	3	1 15 0	10 3 0	20 10 0	Mr. Sweeting.
Dover - - -	4	3	6 0 0	33 0 0	48 1 0	Do.
Driffield - - -	8	3	2 4 0	17 4 0	29 2 0	Dr. Parsons.
Durham - - -	5	3	22 15 0	53 16 0	99 10 0	„ Copeman.
Dursley - - -	3	1	—	—	6 10 0	„ Blaxall.
Easington - -	6	2	45 18 0	70 9 0	116 7 0	Dr. Copeman.
East Hampstead - -	4	1	—	—	10 9 0	Mr. Sweeting.
Eastry - - -	7	4	4 0 0	20 14 0	47 1 0	Do.
East Stonehouse - -	1	1	—	—	25 16 0	Dr. BruceLow.
Elham - - -	5	4	6 10 0	40 19 0	69 3 0	Mr. Sweeting.
Epsom - - -	9	7	2 19 0	12 18 0	59 4 0	Do.
Exeter - - -	1	1	—	—	49 1 0	Dr. Airy.
Farnham - - -	6	5	3 17 0	18 1 0	48 16 0	Mr. Sweeting.
Faringdon - -	4	2	4 9 0	9 8 0	13 1 0	Do.
Faversham - -	4	—	—	—	—	Do.
Festiniog - - -	3	1	—	—	6 15 0	Dr. Parsons.
Foleshill - -	5	2	7 3 0	13 8 0	21 11 0	Do.

App. A. No. 2.

Inspection of Public Vaccination.

UNION.	No. of Vaccination Districts in the Union.	No. of Public Vaccinators recommended for Award.	Range of Awards in each Union. Minimum. £ s. d.	Range of Awards in each Union. Maximum. £ s. d.	Total Sum awarded in each Union. £ s. d.	Medical Inspector.
Forden - - -	4	1	—	—	6 12 0	Dr. Parsons.
Fylde, The - -	5	2	17 3 0	28 8 0	45 11 0	Mr. Thompson.
Garstang - - -	3	2	8 4 0	10 12 0	18 16 0	Mr. Thompson.
Gateshead - -	5	3	36 7 0	192 12 0	274 17 0	Dr. Copeman.
George, St., East - -	1	1	—	—	109 16 0	„ Airy.
Glendale - - -	6	4	1 8 0	6 17 0	14 4 0	Mr. Thompson.
Glossop - - -	2	1	—	—	27 3 0	Dr. BruceLow.
Gloucester - -	2	1	—	—	3 10 0	„ Blaxall.
Godstone - - -	5	4	6 17 0	9 7 0	31 18 0	Mr. Sweeting.
Goole - - -	4	3	8 2 0	50 17 0	71 16 0	Dr. Parsons.
Guildford - - -	9	7	7 15 0	21 7 0	97 0 0	Mr. Sweeting.
Haltwhistle - -	4	4	0 8 0	6 5 0	11 3 0	Mr. Thompson.
Hambledon - -	5	2	6 15 0	9 12 0	16 7 0	„ Sweeting.
Hampstead - -	1	1	—	—	20 3 0	Dr. Airy.
Hardingstone - -	3	3	5 5 0	8 2 0	20 11 0	„ BruceLow.
Hartismere - -	5	1	—	—	11 6 0	„ Airy.
Hartlepool - -	3	2	40 13 0	66 6 0	106 19 0	„ Copeman.
Haslingden - -	6	4	10 3 0	45 3 0	119 17 0	Mr. Thompson.
Hatfield - - -	3	1	—	—	2 10 0	Dr. BruceLow.
Hawarden - -	3	1	—	—	10 13 0	„ Parsons.
Hayfield - - -	1	1	—	—	27 9 0	„ BruceLow.
Helmsley - - -	2	1	—	—	8 19 0	Mr. Sweeting.
Hemel Hempstead -	4	3	5 14 0	10 6 0	22 18 0	Dr. BruceLow.
Hertford - - -	5	2	4 15 0	17 14 0	22 9 0	Do.
Hexham - - -	11	6	0 8 0	10 12 0	20 18 0	Mr. Thompson.
Highworth and Swindon	4	1	—	—	12 13 0	Dr. Blaxall.
Hitchin - - -	5	4	10 0 0	24 8 0	57 2 0	„ BruceLow.
Holbeck - - -	1	1	—	—	25 6 0	„ Barry.
Hollingbourn - -	6	2	5 12 0	10 11 0	16 3 0	Mr. Sweeting.
Holsworthy - -	5	3	2 9 0	6 16 0	13 14 0	Dr. BruceLow.
Holyhead - - -	3	2	4 3 0	8 17 0	13 0 0	„ Parsons.
Holywell - - -	5	2	14 1 0	15 2 0	29 3 0	Do.
Hoo - - -	1	1	—	—	12 9 0	Mr. Sweeting.
Houghton-le-Spring -	3	2	16 9 0	30 11 0	47 0 0	Dr. Copeman.
Howden - - -	4	2	4 19 0	7 19 0	12 18 0	„ Parsons.

UNION.	No. of Vaccination Districts in the Union.	No. of Public Vaccinators recommended for Award.	Range of Awards in each Union. Minimum.	Range of Awards in each Union. Maximum.	Total Sum awarded in each Union.	Medical Inspector.
			£ s. d.	£ s. d.	£ s. d.	
Hoxne - - -	8	5	1 5 0	6 0 0	18 8 0	Dr. Airy.
Huddersfield - -	16	7	9 8 0	58 14 0	194 2 0	Mr. Sweeting.
Hungerford - -	5	2	6 11 0	7 12 0	14 3 0	Do.
Huntingdon - -	5	4	5 0 0	10 17 0	26 4 0	Dr. Airy.
Ipswich - - -	1	1	—	—	65 18 0	Dr. Airy.
Islington - - -	5	—	—	—	—	Do.
Ives, St. - - -	5	4	5 6 0	8 13 0	25 19 0	Do.
Kettering - - -	4	3	4 9 0	15 2 0	28 10 0	Dr. BruceLow.
Kingsbridge - -	5	2	3 15 0	6 11 0	10 6 0	„ Ballard.
Kingston-on-Thames -	11	8	2 15 0	42 1 0	73 18 0	Mr. Sweeting.
Kirkby Moorside - -	1	—	—	—	—	Do.
Lancaster - - -	5	4	8 8 0	64 8 0	94 8 0	Mr. Thompson.
Lanchester - -	4	2	27 4 0	79 4 0	106 8 0	Dr. Copeman.
Leigh - - -	3	3	24 5 0	80 2 0	152 9 0	Mr. Thompson.
Lewisham - -	5	4	14 16 0	20 16 0	71 7 0	Dr. Airy.
Leyburn - - -	6	4	0 14 0	6 3 0	15 18 0	„ Barry.
Llanfyllin - - -	5	4	4 7 0	8 18 0	29 15 0	„ Parsons.
Llanrwst - - -	3	2	4 0 0	12 5 0	16 5 0	Do.
London, City of - -	2	2	9 6 0	13 2 0	22 8 0	„ Airy.
Longtown - - -	2	1	—	—	8 12 0	Mr. Thompson.
Lunesdale - - -	4	1	—	—	3 5 0	Do.
Machynlleth - -	4	3	3 6 0	5 17 0	14 10 0	Dr. Parsons.
Maidstone - -	5	4	2 11 0	50 0 0	75 12 0	Mr. Sweeting.
Malling - - -	5	—	—	—	—	Do.
Malmesbury - -	4	—	—	—	—	Dr. Blaxall.
Malton - - -	6	2	4 7 0	5 8 0	9 15 0	Mr. Sweeting.
Manchester - -	3	2	106 18 0	112 9 0	219 7 0	Dr. Airy.
Marylebone - -	2	2	57 18 0	85 9 0	143 7 0	Do.
Medway - - -	3	2	51 11 0	69 19 0	121 10 0	Mr. Sweeting.

App. A. No. 2.

Inspection of Public Vaccination.

UNION.	No. of Vaccination Districts in the Union.	No. of Public Vaccinators recommended for Award.	Range of Awards in each Union.		Total Sum awarded in each Union.	Medical Inspector.
			Minimum.	Maximum.		
			£ s. d.	£ s. d.	£ s. d.	
Meriden - - -	3	3	1 12 0	6 10 0	12 12 0	Dr. Parsons.
Mildenhall - -	2	2	9 7 0	9 14 0	19 1 0	„ Airy.
Mile End Old Town -	2	2	78 11 0	78 12 0	157 3 0	Do.
Milton - - -	2	1	—	—	50 19 0	Mr. Sweeting.
Morpeth - - -	9	2	4 18 0	10 13 0	15 11 0	„ Thompson.
Mutford and Lothingland.	3	3	29 4 0	66 12 0	134 9 0	Dr. Airy.
Neot's, St. - - -	6	6	1 0 0	14 8 0	28 6 0	Dr. Airy.
Newbury - -	3	1	—	—	9 9 0	Mr. Sweeting.
Newcastle-on-Tyne -	3	4	30 11 0	80 13 0	199 9 0	Dr. Airy.
Newent - - -	3	3	6 9 0	9 13 0	23 1 0	„ Blaxall.
Newton Abbot - -	12	7	2 16 0	31 11 0	91 5 0	„ BruceLow.
Newtown and Llanidloes.	4	1	—	—	4 17 0	„ Parsons.
Northallerton - -	4	1	—	—	4 0 0	Mr. Sweeting.
Northampton - -	4	3	1 6 0	9 0 0	18 1 0	Dr. BruceLow.
Northleach - -	4	4	1 10 0	4 16 0	13 7 0	„ Blaxall.
Nuneaton - - -	2	1	—	—	7 18 0	„ Parsons.
Oakham - - -	3	2	2 9 0	17 13 0	20 2 0	Dr. BruceLow.
Okehampton - -	6	3	5 15 0	16 4 0	28 3 0	Do.
Oldham - - -	6	2	3 13 0	23 4 0	26 17 0	Mr. Thompson.
Oundle - - -	4	3	6 7 0	9 9 0	24 3 0	Dr. BruceLow.
Ouseburn, Great - -	5	3	3 9 0	13 16 0	25 8 0	Mr. Sweeting.
Pateley Bridge - -	2	—	—	—	—	Mr. Sweeting.
Patrington - -	5	2	1 13 0	4 11 0	6 4 0	Dr. Parsons.
Peterborough - -	7	6	3 3 0	53 8 0	101 12 0	„ Bruce-Low.
Pickerin - - -	3	2	2 3 0	10 13 0	12 16 0	Mr. Sweeting.
Plomesgate - -	6	6	2 1 0	10 9 0	43 18 0	Dr. Airy.
Plymouth - - -	1	2	41 3 0	41 0	82 10 0	„ Ballard.

UNION.	No. of Vaccination Districts in the Union.	No. of Public Vaccinators recommended for Award.	Range of Awards in each Union.		Total Sum awarded in each Union.	Medical Inspector.
			Minimum.	Maximum.		
			£ s. d.	£ s. d.	£ s. d.	
Plympton St. Mary -	5	5	5 11 0	8 18 0	36 8 0	Dr. BruceLow.
Pocklington - -	6	3	5 12 0	11 15 0	23 3 0	Do.
Potterspury - -	4	2	1 9 0	18 11 0	20 0 0	Do.
Preston - - -	4	4	14 11 0	131 7 0	261 6 0	Mr. Thompson.
Pwllheli - - -	5	3	5 11 0	7 19 0	19 13 0	Dr. Parsons.
Reading - - -	1	1	—	—	121 5 0	Mr. Sweeting.
Reeth - - -	2	2	3 1 0	6 11 0	9 12 0	Dr. Barry.
Reigate - - -	4	3	5 17 0	27 10 0	43 10 0	Mr. Sweeting.
Richmond (Surrey) -	3	3	13 8 0	39 16 0	68 18 0	Do.
Richmond (Yorks) -	5	4	2 16 0	9 13 0	19 2 0	Dr. Barry.
Risbridge - - -	5	5	4 6 0	27 0 0	55 17 0	„ Airy.
Rochdale - - -	6	4	3 18 0	95 3 0	125 0 0	Mr. Thompson.
Romney Marsh - -	3	2	7 1 0	8 0 0	15 1 0	„ Sweeting.
Rothbury - - -	6	2	2 18 0	4 15 0	7 13 0	„ Thompson.
Royston - -	6	3	7 0 0	17 11 0	34 13 0	Dr. BruceLow.
Rugby - - -	8	6	1 15 0	15 18 0	34 14 0	„ Parsons.
Ruthin - - -	3	1	—	—	5 0 0	Do.
Salford - - -	4	4	44 2 0	98 11 0	297 7 0	Dr. Airy.
Samford - - -	4	3	4 11 0	8 13 0	18 7 0	Do.
Scarborough - -	5	4	3 10 0	20 9 0	33 3 0	„ Barry.
Sculcoates - - -	6	3	14 12 0	106 2 0	215 1 0	„ BruceLow.
Sedgefield - - -	4	3	13 13 0	27 12 0	62 15 0	„ Copeman.
Selby - - -	4	4	1 18 0	35 11 0	60 12 0	„ Parsons.
Settle - - -	7	6	0 10 0	4 17 0	12 13 0	„ Barry.
Shardlow - - -	8	6	7 5 0	62 3 0	126 13 0	„ BruceLow.
Sheppey - - -	2	2	9 0 0	39 0 0	48 0 0	Mr. Sweeting.
Skipton - - -	8	2	3 0 0	16 17 0	19 17 0	Dr. Barry.
Skirlaugh - - -	5	1	—	—	6 12 0	„ Parsons.
Solihull - - -	4	3	4 2 0	13 1 0	23 15 0	Do.
Southam - - -	4	3	1 19 0	8 19 0	17 0 0	Do.
Southmolton - -	9	5	2 15 0	9 6 0	29 16 0	„ BruceLow.
South Shields - -	3	2	85 18 0	100 14 0	186 12 0	„ Copeman
Stockton - - -	3	2	15 5 0	48 6 0	63 11 0	Do.
Stoke Damerel - -	2	2	27 17 0	31 15 0	59 12 0	„ BruceLow.

App. A. No. 2.

Inspection of Public Vaccination.

UNION.	No. of Vaccination Districts in the Union.	No. of Public Vaccinators recommended for Award.	Range of Awards in each Union. Minimum.	Range of Awards in each Union. Maximum.	Total Sum awarded in each Union.	Medical Inspector.
			£ s. d.	£ s. d.	£ s. d.	
Stow	7	5	2 6 0	15 5 0	53 9 0	Dr. Airy.
Stow-on-the-Wold	2	1	—	—	6 15 0	„ Blaxall.
Stratford-on-Avon	7	4	5 11 0	13 12 0	34 7 0	„ Parsons.
Stroud	6	3	5 18 0	19 9 0	33 7 0	„ Blaxall.
Sudbury	7	6	1 19 0	27 16 0	86 18 0	„ Airy.
Sunderland	5	4	52 11 0	73 8 0	250 19 0	„ Copeman.
Tadcaster	5	3	0 18 0	26 7 0	49 11 0	Dr. Parsons.
Tavistock	8	5	3 3 0	11 5 0	35 10 0	„ Ballard.
Teesdale	6	5	4 8 0	21 4 0	59 18 0	„ Copeman.
Tenterden	6	—	—	—	—	Mr. Sweeting.
Tetbury	2	—	—	—	—	Dr. Blaxall.
Tewkesbury	4	1	—	—	2 19 0	Do.
Thanet, Isle of	4	2	11 10 0	50 8 0	61 18 0	Mr. Sweeting.
Thingoe	8	7	1 13 0	6 13 0	31 15 0	Dr. Airy.
Thirsk	6	6	1 10 0	10 1 0	21 1 0	Mr. Sweeting.
Thomas, St.	16	10	1 1 0	21 17 0	59 3 0	Dr. BruceLow.
Thornbury	4	1	—	—	11 9 0	„ Blaxall.
Thorne	6	3	3 13 0	4 15 0	12 13 0	„ BruceLow.
Thrapston	5	2	5 7 0	10 10 0	15 17 0	Do.
Tiverton	13	9	0 17 0	15 13 0	50 12 0	Do.
Todmorden	2	2	10 5 0	27 7 0	37 12 0	„ Barry.
Tonbridge	6	3	10 10 0	25 9 0	47 5 0	Mr. Sweeting.
Torrington	5	4	2 12 0	9 14 0	22 9 0	Dr. BruceLow.
Totnes	13	7	0 17 0	14 0 0	43 12 0	Do.
Towcester	4	2	6 0 0	6 1 0	12 1 0	Do.
Tynemouth	7	4	18 12 0	57 17 0	163 16 0	Mr. Thompson.
Ulverstone	7	7	3 8 0	47 14 0	105 15 0	Mr. Thompson.
Uppingham	4	2	5 1 0	13 19 0	19 0 0	Dr. BruceLow.
Wakefield	6	4	29 10 0	71 0 0	199 3 0	Dr. BruceLow.
Wallingford	3	1	—	—	15 8 0	Mr. Sweeting.
Wangford	2	1	—	—	24 13 0	Dr. Airy.
Wantage	6	3	5 1 0	10 3 0	21 17 0	Mr. Sweeting.

UNION.	No. of Vaccination Districts in the Union.	No. of Public Vaccinators recommended for Award.	Range of Awards in each Union. Minimum.	Range of Awards in each Union. Maximum.	Total Sum awarded in each Union.	Medical Inspector.
			£ s. d.	£ s. d.	£ s. d.	
Ware - - -	8	6	2 7 0	16 6 0	43 15 0	Dr. Bruce Low.
Warwick - - -	3	1	—	—	14 7 0	„ Parsons.
Watford - - -	4	3	7 4 0	16 19 0	36 16 0	„ Bruce Low.
Weardale - - -	5	5	1 18 0	15 9 0	41 2 0	„ Copeman.
Wellingborough - -	5	5	4 4 0	25 3 0	65 18 0	„ Bruce Low.
Welwyn - - -	1	1	—	—	4 3 0	Do.
Westbury-on-Severn -	4	4	6 3 0	17 19 0	44 13 0	„ Blaxall.
Wetherby - - -	6	3	4 10 0	9 10 0	18 14 0	Mr. Sweeting.
Wharfedale - -	4	2	8 4 0	16 11 0	24 15 0	Do.
Wheatenhurst - -	2	2	4 6 0	6 1 0	10 7 0	Dr. Blaxall.
Whitehaven - -	6	4	19 8 0	25 6 0	93 4 0	Mr. Thompson.
Winchcomb - -	2	1	—	—	10 9 0	Dr. Blaxall.
Windsor - - -	3	1	—	—	37 16 0	Mr. Sweeting.
Wokingham - -	4	3	8 13 0	11 17 0	30 10 0	Do.
Woodbridge - -	4	4	9 17 0	12 19 0	45 7 0	Dr. Airy.
Woolwich - -	4	4	4 6 0	68 14 0	118 18 0	Do.
Wrexham - - -	5	2	5 13 0	51 13 0	57 6 0	„ Parsons.
Total - -	1,256	809	—	—	13,624 15 0	

App. A. No. 3.

National Vaccine Establishment.

No. 3.

Statistics of the National Vaccine Establishment and Educational Vaccination Stations.

I.—Staff at end of 1891.

N.B.—The Stations named in *italics* are Educational Vaccination Stations authorised by the Local Government Board.

Description of Vaccinator.	Name of Vaccinator.	Vaccination Stations.	Days and Hours of Attendance.
Vaccinators supplying lymph for the public service, & salaried from the Parliamentary grant.	1. Dr. R. Cory	*Surrey Chapel*	Tues., Thurs.; 2.
	2. Mr. Joseph Loane	*Tottenham Court Chapel.*	Mon., Wednes.; 1.
Parochial and other Vaccinators not salaried from the Parliamentary grant, but contributing lymph at a fixed rate of payment.	1. Mr. Ellis S. Guest	*Manchester*	Monday; 2.
	2–6. Dr. Edmund Robinson.	*Birmingham*	Monday, Tuesday, Wednesday } 11. Wednesday; 2. Thursday; 11.
	7. Mr. N. E. Roberts	*Liverpool*	Tuesday; 1.
	8. Mr. E. L. Webb	*Pimlico*	Thursday; 10.
	9. Mr. J. Hawthorn	*Newcastle-on-Tyne.*	Wednesday; 3.
	10. Mr. E. L. Webb	Westminster	Tuesday; 10.
	11–12. Mr. E. C. Greenwood	*Marylebone*	Tuesday; 2. Wednesday; 10.
	13. Mr. J. Loane	*Whitechapel*	Wednesday; 11.
	14. Mr. Frederick Holmes	*Leeds*	Tuesday; 2.30.
	15. Dr. Edward Lynes	Coventry	Tuesday; 12.
	16–17. Dr. Hugh Thomson	*Glasgow*	Monday; 2. Mon., Thurs.; 12.
	18. Mr. J. F. Staine	*Endell Street*	Tuesday; 10.
	19. Mr. W. Skinner	*Sheffield*	Tuesday; 3.
	20. Dr. A. C. Clarke	Salford	Thursday; 2.
	21. Dr. G. A. Miskin	Waterloo	Tuesday; 2.
	22. Dr. J. B. Buist	*Edinburgh*	Thursday; 3.
	23. Dr. R. Cory	*St. Thomas's Hosp.*	Wednesday; 11.30.
	24. Mr. Wm. McLennan	*Glasgow West*	Monday 1
Teachers of Vaccination not supplying lymph.	Dr. W. Husband	*Edinburgh*	Wednes., Sat.; 12.
	Mr. H. Lawrence	*Bristol*	Wednesday; 10.
	Mr. William A. Budd	*Exeter*	Thursday; 3.
	Mr. V. A. Jaynes	*Horsleydown*	Wednesday; 3.
	Dr. A. N. Montgomery	*Dublin*	Tues., Fri.; 10.
	Mr. R. Cory	*Cambridge*	Friday; 11.

II.—Animal Vaccine Station.

The Animal Vaccine Station is at 95, Lamb's Conduit Street, where Dr. R. Cory and Mr. T. S. Stott attend for the Vaccination of Children on Tuesdays and Thursdays, at 10.30 a.m.

III.—Sources and Amount of Lymph Supply in 1891.

N.B.—The Stations named in *italics* are Educational Vaccination Stations authorised by the Local Government Board.

Description of Vaccinators.	Vaccination Stations.	Number of Vaccinations performed at the Stations respectively.		Number of Charges of Lymph supplied from the Stations respectively.	
		Primary.	Re-vaccinations.	Charged Ivory Points.	Charged Tubes each estimated as equal to 10 Ivory Points.
Vaccinators salaried from the Parliamentary grant.	1. *Surrey Chapel*	185	11	273	—
	2. *Tottenham Court Chapel.**	311	9	—	23
	Total -	496	20	273	23
Parochial and other Vaccinators not salaried from the Parliamentary grant, but contributing lymph at a fixed rate of payment.	1. *Manchester* -	982	1	—	336
	2–6. *Birmingham* -	3,660	267	—	1,155
	7. *Liverpool* -	669	5	—	447
	8. *Pimlico* - -	417	19	—	107
	9. *Newcastle-on-Tyne.*	581	88	—	36
	10. Westminster† -	578	27	—	38
	11–12. *Marylebone*	788	73	—	—
	13. *Whitechapel* -	2,075	2	—	552
	14. *Leeds* - -	830	7	—	—
	15. Coventry -	499	11	—	302
	16–17. *Glasgow* -	1,240	1	—	119
	18. *Endell Street* -	232	35	—	49
	19. *Sheffield* - -	906	—	—	—
	20. Salford - -	399	—	—	144
	21. Waterloo -	1,337	6	—	1,734
	22. *Edinburgh* -	325	1	—	—
	23. *St. Thomas's Hospital.*	259	9	—	—
	24. *Glasgow West* -	595	23	—	—
	Total -	16,372	575	—	5,019
	Grand Total	16,868	595	273	5,042

* For ten months only.
† For eleven months only.

App. A. No. 3.

National Vaccine Establishment.

III.—Sources and Amount of Lymph—*continued.*

During the year, additional supplies (to the extent of 3,540 charged tubes) were obtained from the following gentlemen:—

Dr. W. H. Kempster, Battersea East.
Dr. T. N. Orchard, Pendleton.
Dr. T. M. Johnson, Salford.
Mr. J. Bark, Kirkdale.
Dr. R. S. Archer, Everton.
Dr. F. Cadell, Edinburgh.
Mr. A. Meeson, Toxteth Park.
Mr. J. B. Mann, Manchester.
Dr. R. F. Cook, Gateshead.
Dr. G. A. Miskin, Kennington.

IV.—Distribution of Human Lymph, 1891.

Number of applications:

From Medical Practitioners in England and Wales	4,800
,, ,, ,, Scotland	181
,, the Army	23
,, the Navy and from the Emigration Department	28
,, India and the Colonies	62
,, Diplomatic and other Foreign Services	22

Supplies sent out:—

Charged ivory points	284
,, capillary tubes	7,610

V.—Distribution of Calf-Lymph, 1891.

Number of applications	3,320

Supplies received:—

Charged ivory points	14,002
,, capillary tubes	56

Supplies sent out:—

Charged ivory points	13,977
,, capillary tubes	56

No. 4.

On the Operations of the Animal Vaccine Station at Lamb's Conduit Street, during the Year 1891–92; by Dr. Cory.

During the year 1st April 1891 to 31st March 1892, 336 calves were vaccinated at Lamb's Conduit Street for the purposes of that station. Of these calves 269 were males and 67 females.

The aggregate weight on reception at Lamb's Conduit Street of the 336 calves was, males, 62,174 lbs., females, 20,059 lbs. On dismissal from the station their weights were respectively 71,950 lbs. and 21,620 lbs. So that during retention for vaccination purposes calves of both sexes gained considerably in weight; males by an average of 36·3 lbs., females by an average of 23·3 lbs.

Of the above calves 316 were vaccinated with lymph directly derived from other calves, and 20 were vaccinated with calf lymph which had been stored. 14,802 insertions in the 316 calf-to-calf operations produced 14,245 vesicles, or 96·2 per cent.; and 978 insertions in 20 stored lymph operations produced 948 vesicles, or 96·9 per cent. No material difference in the results of calf-to-calf vaccinations was observed, whether the lymph used was from calves vaccinated 96, or from calves vaccinated 120 hours previously. In both cases the rate of insertion success was above 96·2 per cent.

As to the body temperature of calves under vaccination, Chart A. gives the temperature day by day of calves, male and female, before and after vaccination; the data in each instance representing the mean of a number of determinations of the temperature of the rectum in different calves.

For purposes of comparison there is added Chart B., which gives on similar scale the mean temperature, taken daily in the rectum, of four infants undergoing vaccination.

It thus appears that the temperature of the average female calf, before and during vaccination, is lower somewhat than that of the average male calf, and that the average temperature of the human infant under vaccination is several degrees lower than that of calves. Further it appears that the maximum rise of temperature in the vaccinated infant though higher relatively than the maximum rise in the vaccinated calf, occurs at a later stage of vaccination; and this notwithstanding that the calf is commonly vaccinated by upwards of 70, whereas the infant is vaccinated by no more than five, insertions of lymph.

The higher temperature, before as well as after vaccination, of the calf as compared with the human infant, is of particular interest. For it may be thought of as related to the observed earlier maturation in the calf than in the human subject of the vesicles induced by vaccination; and as perhaps, or in some degree at last, accounting for the circumstance that lymph taken for the purposes of further vaccination from the calf *on the fifth day* of vaccination corresponds, as regards activity and keeping quality, with lymph taken on the *eighth day* from the human infant.

Primary Vaccinations.—During the year 1891–92, 7,529 persons received primary vaccination at the station, five separate insertions of lymph being made in each instance. Of these persons, 3,716 were males and 3,813 females. Of the 7,529 primary vaccinations, 81 were of persons who failed to return for inspection; and of the remaining 7,448, all but 18 succeeded at the first attempt, and in no case was

a third attempt at vaccination requisite. The amount of insertion success obtained by each of three several operators was as follows: of 742 persons primarily vaccinated by Mr. Stott, 6 failed to return for inspection, and one was vaccinated round a nœvus. Of the 735 remaining, 615 were on examination found to have taken in five places, 67 in four, 25 in three, 12 in two, 10 in one, and 6 were not successful on the first attempt. Mr. Stott's insertion success-rate therefore was 93·93 per cent.

Of 218 persons primarily vaccinated by Dr. Savory, acting for Mr. Stott or myself in the absence of one or other of us, one failed to return for inspection, and three were vaccinated round nœvi. Of those remaining, 198 were found to have taken in five places, 11 in four, 2 in three, 1 in two, 1 in one, and 1 did not succeed on the first attempt. Dr. Savory's success, therefore, was 97·48 per cent.

Of 6,569 persons primarily vaccinated by myself, 74 failed to return for inspection, and other 9, all of whom were operated on for the cure of nœvi, are not taken into account in these statistics. Of the 6,486 remaining, 6,106 were found to have taken in five places, 231 in four, 78 in three, 35 in two, 25 in one only, while in 11 cases vaccination proved unsuccessful on first trial; an insertion success-rate of 98 per cent.

Revaccinations.—These during the year numbered 321. Mr. Stott performed 48, Dr. Savory 3, and I myself 270. Of these latter, 231 were successful in five places, 16 in four, 8 in three, 3 in two, 3 in one, and 1 was unsuccessful at first trial; other 6 did not return for inspection. My inspection success-rate therefore in re-vaccinations was 94·85 per cent. Mr. Stott's success-rate among his 48 cases was 95·83 per cent.

Of the 7,850 persons vaccinated or re-vaccinated at the station, 74 returned after "inspection" on account of indisposition or of irregularity complicating their vaccination. For the most part these were cases of "sore arms," but among the 74 there were 14 cases of transient eruption, 2 of boils, 4 of axillary abscess, and 5 of erysipelas.

Of infants vaccinated at the station, 4 deaths were heard of as having occurred during the course of or not long after their vaccination. All of them were made matter of investigation by the Vaccination Commission.

Chart A.

Showing Temperature of Vaccinated Calves.

[The continuous line represents the temperature of males, the intercepted line that of females.]

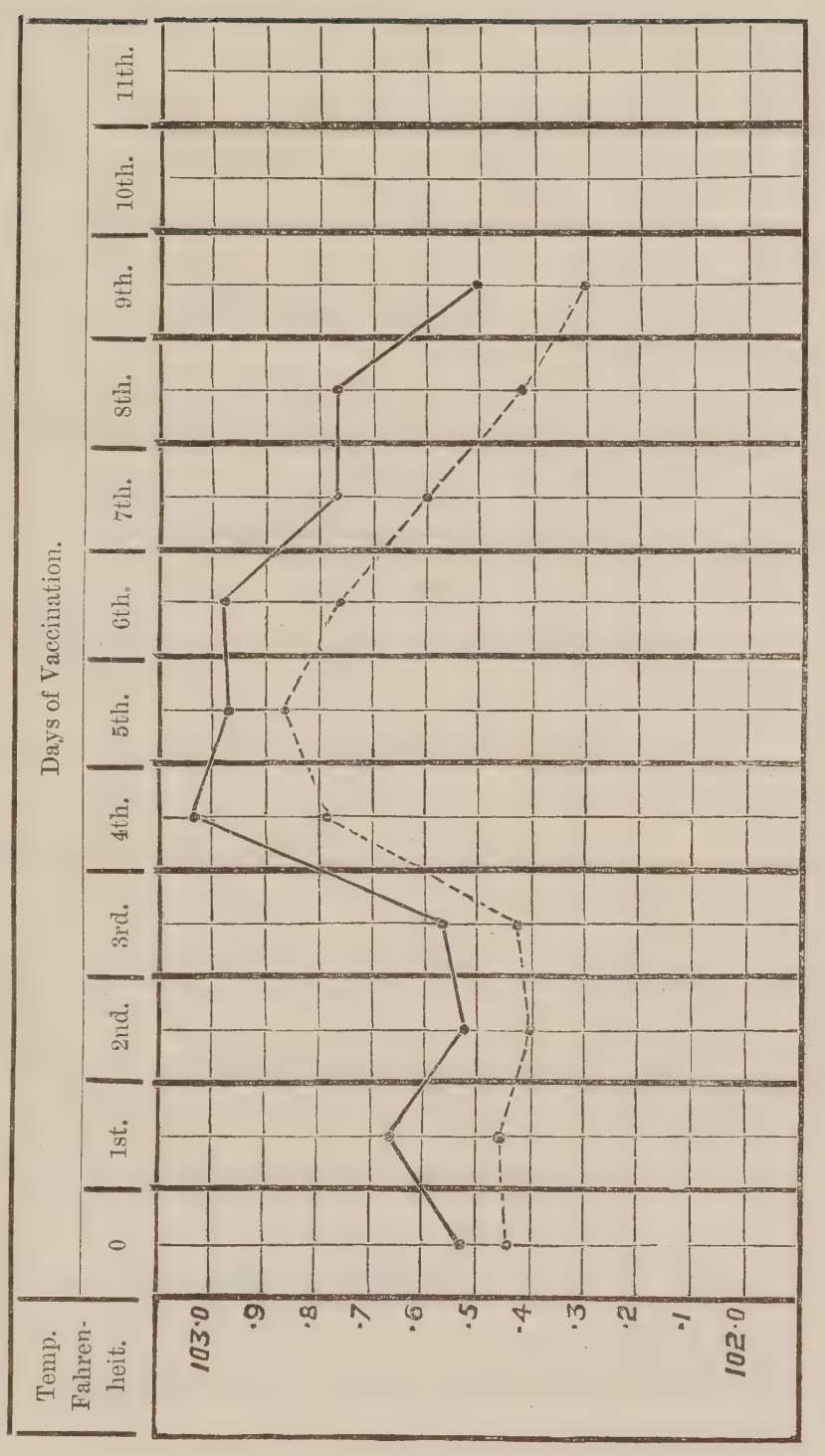
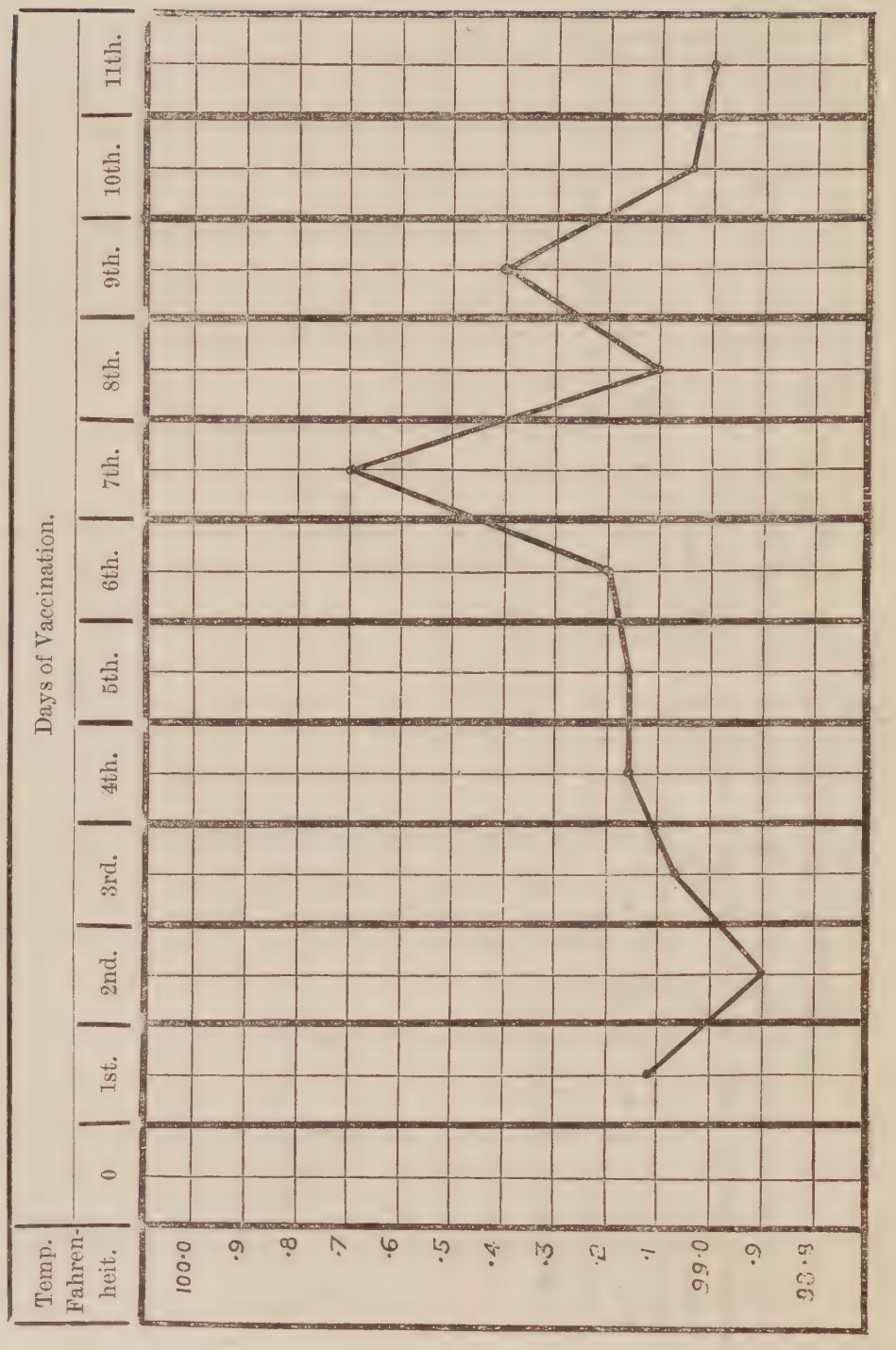


Chart B.

Showing the Temperature of Vaccinated Infants.

[As regards day of vaccination, temperature taken after performance of the operation.]



No. 5.

Abstract of Medical Inspections made in 1891 with regard to the Incidence of Disease on particular places, and to questions concerning Local Sanitary Administration.

1. Aylesbury Rural Sanitary District (Bucks); population (1891), 16,664; Dr. Theodore Thomson.

   Sanitary Authority: Aylesbury R.*

   Ground of Inquiry: Diphtheria: Local complaint as to neglect generally by the Guardians of their functions as Sanitary Authority.

   Chief Facts reported by Inspector: Dwellings of the district in large number of instances old, damp, and dilapidated; drainage arrangements for the most part absent or defective; ultimate disposal of sewage usually into brooks or ditches; prevailing method of excrement disposal by privies connected with cesspits; refuse and excrement removal cast on the occupier; greater part of water supply from shallow wells sunk in clay and liable to contamination; nuisances from keeping of animals, from refuse accumulations, and from imperfect drainage and excrement disposal; no hospital or ambulance provision for infectious sickness; sanitary administration inadequate.

2. Bush Hill Park (Middlesex); estate of 370 houses; Dr. Copeman.

   Sanitary Authorities: Enfield U. and Edmonton U.,* and Lexden and Winstree R.

   Ground of Inquiry: Scarlatina.—Report of Medical Officer of Health.

   Chief Facts reported by Inspector: Outbreak, limited to eight consecutive days in November, of scarlatina within a circumscribed area on the borders of each of two urban sanitary districts near London. No sort of community of condition among the households invaded except in the matter of milk supply. This milk, distributed by a local tradesman, but derived from a farm at a village many miles distant in Essex, where also there occurred, simultaneously with the scarlatina among customers of the above local tradesman, attacks by the disease among persons obtaining milk from the particular farm. Infection of milk at the farm from a human source not discoverable, but cows there found to be suffering from udder eruption. (*See* p. 69 of present volume.)†

3. Cumberworth (Yorks, W.R.); population (1891), 1,417; Dr. Barry.

   Sanitary Authority: Cumberworth U.

   Ground of Inquiry: Representation from West Riding County Council to the effect that the Public Health Act, 1875, had not been properly administered in the District.

* Throughout this abstract "R." denotes "Rural Sanitary Authority," and "U.," "Urban Sanitary Authority."

† Report produced as App. A. No. 8 of present volume.

App. A. No. 5.

Abstract of Medical Inspections.

Chief Facts reported by Inspector: General neglect of Sanitary Authority to carry out the powers entrusted to them under the Public Health Acts. Water supply defective and polluted; sewerage defective; house drainage rudimentary; offensive midden privies; scavenging neglected. Many houses damp and insufficiently ventilated. No provision for isolation of persons suffering from infectious disease. No byelaws. No voluntary Acts adopted.

4. Foleshill Rural Sanitary District (Warwickshire); population, 19,968; Dr. Parsons.

Sanitary Authority: Foleshill R.

Ground of Inquiry: Prevalence of "fever"; Registrar-General's returns.

Chief Facts reported: Enteric fever prevalent, chiefly at Bedworth; cases occurring sporadically, with occasional sudden localised outbreaks confined to persons drinking water from particular wells. In the remainder of the district, "fever" less prevalent, and not specially localised.

Bedworth is a small but closely-built town with many confined courts. Old highway drains are used as sewers, although of unsuitable construction, and without proper flushing and ventilation; nuisance from road gullies and at outfall; house drains also defective. Privy accommodation insufficient, privies connected with large deep wet middensteads, extremely offensive, and often very near to houses and wells. Removal of refuse contracted for, but inadequately performed. Water supply from shallow wells scanty and impure.

In the remainder of the district, similar sanitary defects of frequent occurrence, but usually less aggravated in degree than at Bedworth, owing to the houses being less closely aggregated together. No comprehensive action by Rural Sanitary Authority as regards sewerage or water supply. No public scavenging except at Bedworth. No urban powers or byelaws, though these are much needed. Notification of infectious diseases in force, but no hospital accommodation for the isolation of infectious cases, and no disinfecting apparatus.

5. Hepworth (Yorks, W.R.); population (1891), 1,008; Dr. Barry.

Sanitary Authority: Hepworth U.

Ground of Inquiry: Representation from the West Riding County Council to the effect that the Public Health Act, 1875, had not been properly administered in the District.

Chief Facts reported by Inspector: Sanitary administration very insufficient prior to transmission of representation by County Council to Board. Since then improved. Water supply liable to pollution throughout district. No water supply at Jackson Bridge. Pipes recently substituted for rubble drains at Hepworth. House drains except at Hepworth chiefly of rubble and otherwise defective. Excrement disposed of in privy middens. Scavenging left to occupiers. No byelaws. No means for isolation of infectious diseases.

6. Kirkheaton (Yorks, W.R.); population (1891), 2,632; Dr. Barry.

Sanitary Authority: Kirkheaton U.

Ground of Inquiry: Representation from the West Riding County Council to the effect that the Public Health Act, 1875, had not been properly administered in the District.

Chief Facts reported by Inspector: Water supply for upwards of half houses from Huddersfield Corporation Waterworks; for remaining houses water obtained from dip wells and other sources liable to pollution. Sewerage unsatisfactory and defective. Sewage discharged without treatment into watercourses giving rise to nuisance. Excrement disposal by midden privies, almost universally badly constructed and badly placed. Scavenging left to occupiers, and much neglected. Dampness of houses owing to defective construction, and to want of paving and surface drainage. Administration of Sanitary Authority inefficient. Byelaws obsolete. No isolation hospital provided. (*See* p. 41 of present volume.)*

7. Lepton (Yorks, W. R.); population (1891), 2,855; Dr. Barry.

Sanitary Authority: Lepton U.

Ground of Inquiry: Representation from West Riding County Council to the effect that the Public Health Act, 1875, had not been properly administered in the District.

Chief Facts reported by Inspector: Water supply for about half population from Huddersfield Corporation Waterworks; for remainder from dip wells, dip troughs, &c., liable to pollution, and frequently unreasonably distant. Sewers partly rubble and partly pipe. Sewage discharged, as a rule, into nearest watercourse. House drainage generally of rubble. Some improvements during recent years. Excrement disposed of in imperfect midden privies. Scavenging left to occupiers, and neglected. Building and other byelaws not enforced. No means provided for securing notification or isolation of cases of infectious disease, or for disinfection. General inaction as regards suppression of nuisances, except as a consequence of pressure from the Local Government Board.

8. Raunds; population (estimated), 3,350; and Heyford; population (1891), 925; Dr. Bruce Low.

Sanitary Authorities: Thrapston R. and Northampton R.

Ground of Inquiry: Epidemic of pneumonia reported in daily papers.

Chief Facts reported by Inspector: Raunds: Prevalence of anomalous illness characterised by pneumonia, and sometimes by meningeal symptoms, and frequently associated with tonsilitis; mainly attacking young children; spread apparently by personal contact. Evidence of similar illness in other parts of Northamptonshire. Enteric fever endemic. Upwards of 100 cases reported during last two years. Sanitary circumstances of Raunds flagrantly unwholesome. No proper sewerage. Wells liable to contamination. Scavenging inadequate. Sanitary administration by Authority lax. No hospital provision. No system of notification. Medical Officer of Health working under discouragement and difficulty.

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* Report reprinted as App. A. No. 6 of present volume.

Heyford: The current illness, sometimes lobar pneumonia, sometimes capillary bronchitis, with super-addition in certain cases of marked symptoms of cerebro-spinal meningitis, now and again accompanied by tonsilitis and otitis. Sanitary circumstances not markedly unwholesome. No evidence of importation of infection, but sporadic cases resembling those under notice had occurred during the previous 12 months in the parish. (*See* p. 55 of present volume.)*

9. Rawdon; population (1891), 3,077; Dr. Barry.

Sanitary Authority: Rawdon U.

Ground of Inquiry: Re-inspection to ascertain action taken since previous inspection in 1890.

Chief Facts reported by Inspector: Considerable improvements effected since previous inspection; complete sewerage scheme drawn up and approved by local board; application made for Provisional Order to acquire land for sewage disposal. Scavenging undertaken by Sanitary Authority. Bye-laws with respect to new streets and buildings revised. Regulations with respect to dairies, cowsheds, and milkshops put in force. Salary of Medical Officer of Health increased, and house to house survey of district made. Many minor improvements in house drainage, means of excrement disposal, &c. Infectious Disease (Notification) Act, 1889, adopted.

10. Rotherham (Yorks); population (1891), 42,050. Rawmarsh (Yorks); population (1891), 11,893. Greasborough (Yorks); population (1891), 3,217; Dr. Theodore Thomson.

Sanitary Authorities: Rotherham U., Rawmarsh U., and Greasborough U.

Ground of Inquiry: Enteric fever: Reports of Medical Officers of Health.

Chief Facts reported by Inspector: Simultaneous outbreaks of enteric fever, and of "fever" of a less definite sort, in each of these three districts. These outbreaks not due to sewerage or drainage, nor to excrement disposal, nor to milk supply, but to a public water supply common to the invaded parts of each district. The public supply in question, that known as the "high-level" section of the Rotherham waterworks. This section of the water supply shown to have been similarly related to "fever" prevalence in previous years.

11. St. George, Hanover Square (London); population (1891), 78,362; Mr. Sweeting.

Sanitary Authority: The Vestry of St. George, Hanover Square.

Ground of Inquiry: Prevalence of diphtheria in a block of dwellings (Bourdon Buildings).

Chief Facts reported by Inspector: A limited outbreak of diphtheria, preceded by many cases of minor diphtheritic sore-throat. Disproportionate incidence of diphtheria upon persons of school-age, especially upon the children attending

* Report reprinted as App. A. No. 7 of present volume.

South Street School; from which many scholars had been absent, before the outbreak, on account of anomalous throat affections, all probably of a diphtheritic character. The diphtheria spread by personal infection. Removal to hospital practised as soon as the nature of the disease was recognised. School-closure only acquiesced in by Sanitary Authority at close of outbreak.

12. Tees Valley (Yorks, N.R., and Durham); population (1891), 503,616; Dr. Barry.

Sanitary Authorities: Barnard Castle, Darlington, Bishop Auckland, Shildon and East Thickley, Spennymoor, Hartlepool, West Hartlepool, Stockton-on-Tees, Middlesbrough, South Stockton, Ormesby, Normanby, Eston, Kirkleatham, Redcar, Guisborough, Skelton and Brotton, Saltburn-by-the-Sea, Loftus, Northallerton and Richmond U.; Teesdale, Auckland, Darlington, Stockton, Sedgefield, Hartlepool, Northallerton, Stokesley, Middlesbrough, Guisborough, and Richmond R.

Ground of Inquiry: Enteric fever.

Chief Facts reported by Inspector: Recrudescence of epidemic prevalence of enteric fever, occurring suddenly and simultaneously in certain towns and villages supplied with water from the River Tees. Absence of epidemic prevalence of the disease in neighbouring towns and villages obtaining their water supply from sources other than the River Tees.

13. Trawden (Lancashire); population (1891), 2,354; Mr. T. W. Thompson.

Sanitary Authority: Trawden U.

Ground of Inquiry: Deficient and defective privy accommodation and need for more frequent removal of excrement and refuse.

Chief Facts reported by Inspector: Defective privies and ashpits common in connexion with old property, but much improvement being brought about, at instance of Sanitary Authority, by introduction of pail closets and small covered ashpits; a few slop-water "tumbler" closets of Burnley pattern also introduced. Scavenging mostly done by farmers and very unsatisfactory. Cottages as a rule have no garden ground. Old quarry acquired by Sanitary Authority as a depôt for deposit of excrement and refuse not used, hitherto, by inhabitants.

[Sanitary Authority have since undertaken the removal of excrement and refuse.]

14. Townships of Tudhoe; Elvet (part of); Framwellgate (part of); Coxhoe; Gilligate (part of); Pittington; and Sherburn; Mr. T. W. Thompson.

Sanitary Authority: Durham R.

Ground of Inquiry: Need for facts relating to the methods of excrement and refuse disposal.

App. A. No. 5.

Abstract of Medical Inspections.

Chief Facts reported by Inspector: Midden, ash-midden, and privy accommodation generally unsatisfactory, except in the colliery portion of Sherburn village. Middens often of excessive size, uncovered, wet, and too near to dwellings. Privies often very defective and in some instances, as at High and Low Pittington, insufficient for needs of locality. Scavenging (which is usually done by colliery owners or farmers) unsatisfactory, except in the colliery portion of Sherburn village, and in that portion of the township of Tudhoe which is scavenged by Sanitary Authority's contractor.

No. 6.

Report on the Sanitary Circumstances of the Kirkheaton Urban Sanitary District, and upon Administration by the Sanitary Authority; by Dr. F. W. Barry.

In July 1890 a Representation was, under section 19, sub-section 2, of the Local Government (England and Wales) Act, 1888, made by the County Council for the West Riding of Yorkshire, to the Local Government Board, to the effect that it appeared from the Annual Report for 1889 of the Medical Officer of Health for the Urban Sanitary District of Kirkheaton (for copy of this report *see* Addendum A.) that the Public Health Act, 1875, had not been properly put in force in that district. At the same time the County Council requested the Board to institute a local inquiry into the sanitary administration of the district.

Upon the receipt of this Representation, the Board, in accordance with their usual practice, forwarded a copy to the Sanitary Authority for their observations, and to this letter the following reply was received :—

Kirkheaton Local Board.

"24, Queen's Street,
"Huddersfield,
August 29th, 1890.

"Sir,

"Your letter of August 20th was considered by my Board, and I am requested to say that they have not in any way neglected their sanitary duties, and that although technically in the number of cases in the Medical Report of 1889, not completed, appeared large, as a matter of fact they were of a mild nature, and more time was given to various persons in which to remedy, than otherwise would have been.

"The Board can with great satisfaction point to the long-continued healthy state of their district. The death-rate for the year 1889 being 20·25 per 1,000. There were 58 deaths, 34 females and 24 males. Of the deaths, 20 were old people, 7 of whom were over 60 years, 9 over 70, and 4 over 80 years. There were 19 young children under 2 years, 13 of them being under a year. Deaths from zymotic diseases were 5, viz., 3 measles, 1 diarrhœa (child 4 months), and 1 diphtheria, or 1·74 per 1,000.

"The present number of sanitary cases in the inspector's hands are only 18, and none are of serious importance, although they are being carried out with promptitude.

"My Board humbly suggest—

"1st. That there is no necessity for an inquiry.

"2nd. That they have at all times carefully considered the requirements of the district.

"3rd. That they are and will continue watching with the greatest care all matters affecting the public health in their district.

"I have the honour to be,
"Sir,
"Your obedient servant,
"(Signed) E. A. Beaumont,
"Clerk."

Prior to the receipt of the Representation from the County Council, the Board had themselves on the 24th February 1890 addressed a letter to the Kirkheaton Local Board to the following effect :—

"The Board have had under their consideration the Annual Report for 1889 of the Medical Officer of Health to the Kirkheaton Urban Sanitary Authority, a copy of which has been forwarded to the Board, pursuant to their General Order.

App. A. No. 6.
On the Kirkheaton U.S.D.; by Dr. Barry.

"The Board observe from that report that out of 139 sanitary defects reported by the Medical Officer of Health during the year, only 64 had been dealt with at the time the report was made, and they also observe the remarks of the Medical Officer of Health on this subject to the effect that though some of the numerous insanitary conditions to which he drew the attention of the Authority at different times during the year have been remedied, a great part of them yet remains undealt with. I am to request that the Board may, in a short time, be informed what steps the Sanitary Authority have taken, or decided on, to give effect to the recommendations of the Medical Officer of Health, and also those contained in the memorandum of advice which the Board's inspector, Dr. Gresswell, left with the Authority after his inspection of the district in February 1887.

To this letter, on April 10th, the Clerk to the Kirkheaton Local Board replied:—

"That the Sanitary Inspector, in accordance with the order of the Board at a previous meeting, has carefully considered your letter, and reported to my Board to the following effect:—

"'I have carefully considered the letter, and at the same time have again passed under review the whole of the sanitary work of the past year, which has confirmed the remarks in my annual report, that a fair amount of sanitary progress has been made, and although the discrepancy referred to in the letter between 139 sanitary defects reported and 64 dealt with is rather startling, yet an analysis of the missing 75 cases shows that they are generally of inferior importance, and would not in the aggregate seriously interfere with the public health.'

"The latter are receiving prompt attention. The Medical Officer and Sanitary Inspector are giving much attention to the welfare of the district, which is poor, and cannot be pushed on so quickly as a town."

The results of this correspondence not being deemed to be satisfactory, I was instructed to make local inquiry with respect to the sanitary circumstances and administration of the district.

In the following report I propose to give:—(A) a brief description of the sanitary circumstances of the district, and (B), some account of the sanitary administration exercised by the Local Board.

(A)—Sanitary Circumstances of the District.

General Description.—The Urban Sanitary District of Kirkheaton, which is comprised within the Registration District and Union of Huddersfield, has an area of 1,674 acres. On the *North* it is bounded by the River Calder, which here separates it from the Mirfield Urban and the Halifax Rural Sanitary Districts. On the *South* it is bounded by the Kirk Ings or Lane Side Beck, separating it from the Lepton Urban Sanitary District. On the *West* it is contiguous with the County Borough of Huddersfield, from which it is separated north-westward by the River Colne. On the *East* it is contiguous with the Mirfield and Whitley Upper Urban Sanitary Districts. The highest lying area of the district is its central and south-eastern portion, where are attained, at Round About Hill, Cockley Hill, and Stoneroyd respectively, elevations of 600, 625, and 600 feet above Ordnance Datum. The portion of the district sloping northward and north-westward from Round About Hill is situate partly in the drainage area of the Calder and partly in that of the Colne: the lowest lying land herein (150 feet above datum) is traversed by the Calder and Hebble Canal. Due west of Round About Hill there is practically no slope, the boundary line here passing along the summit of a ridge overlooking the Colne Valley, at an average elevation of 350 feet above it. The portion of the district south

of Round About, Cockley, and Stoneroyd Hills has a general slope to the south-west, the lowest point reached being 300 feet above datum. This portion is in the drainage area of the Kirk Ings Beck.

The District, which is semi-rural in character, contains one village, two or three scattered hamlets, and a number of detached farmhouses. The chief centres* of population are:—(*a*) Kirkheaton (381 houses), a long straggling village, situate on the south-western slope at an elevation of from 250 to 450 feet; (*b*) Upper Heaton (34 houses), situate at an elevation of upwards of 500 feet, a little to the north-west of the centre of the district; (*c*) Colne Bridge (73 houses), situate at the north-western extremity of the district on the low ground (elevation of 150 feet), close to the River Colne. [This hamlet forms part of the village of the same name which is in the Borough of Huddersfield, and accordingly this place is within the jurisdiction of two separate Sanitary Authorities]; and (*d*) Houses and Houses Hill (48 houses), a hamlet situate to the south-eastern extremity of the district at an elevation of 400 feet.

Geologically the District is situate on the strata of the Lower Coal Measures, the subsoil consisting either of sandstone (Elland Flags) or of the overlying shale or clay.

The population in 1881 was 2,747 persons, living in 681 houses. At the census of 1891 it was found that the population had decreased to 2,632 persons living in 616 houses. The rateable value is (1891) 11,598*l.* The inhabitants are employed in woollen and cotton manufacture, coal mining, and on small dairy farms.

Dwelling Accommodation.—From the return given in Table I., it will be seem that there are 691 houses (inhabited and uninhabited) upon the ratebooks in the Kirkheaton Urban Sanitary District, and that of these 658, or 95·2 per cent., are of the cottage class, having each a rateable value of under 10*l.*, whilst 550, or 79·6 per cent. of the whole, have rateable values of under 5*l.*

TABLE I.—RETURN of the NUMBER of DWELLING-HOUSES in the KIRKHEATON URBAN SANITARY DISTRICT rated in 1891 at the following RATEABLE VALUES.

Name of Village or Hamlet.	Under 5*l.*	5*l.*-10*l.*	10*l.*-20*l.*	20*l.*-30*l.*	30*l.*-40*l.*	Over 40*l.*	Total.
Kirkheaton -	307	53	18	1	2	—	381
Upper Heaton -	30	2	2	—	—	—	34
Colne Bridge -	57	13	2	—	—	1	73
Houses and Houses Hill -	42	5	1	—	—	—	48
Smaller groups and detached houses - -	114	35	5	—	—	1	155
Totals - -	550	108	28	1	2	2	691
Per cent. of Total -	*79·6*	*15·6*	*4·1*	*0·1*	*0·3*	*0·3*	—

* The distribution of houses here recorded is obtained from the existing ratebooks. See also Table I.

The dwellings are, as a rule, substantially built of stone, and there is comparatively little crowding of houses upon area. There are, however, some back-to-back houses, and one or two courts in the older parts of Kirkheaton. A considerable number of the houses in the district have no means of through ventilation, owing to the absence of back doors and back windows that will open. At Colne Bridge and Upper Heaton many of the houses have a dilapidated and neglected appearance, and several of them are at the present time unoccupied. Some houses, more especially in the outlying parts of the district, were observed to be damp from the want of eavespouts, others from the circumstance that two or more of their walls have been partly built into the bank. At Colne Bridge houses have been erected within recent years where the area procured at the back was under 120 square feet. Thoughout the district very little attention appears to have been paid to the paving of yards, and there is generally inefficiency of surface drainage about houses.

Water Supply.—Upwards of half the inhabited houses of the district—situate in Kirkheaton, Colne Bridge, and Upper Heaton—receive their water supply from the mains of the Huddersfield Corporation; the remaining houses obtain their water from field and roadside dip troughs, cellar wells, and pump wells, which are in many instances so placed as to be liable to pollution.

Sewerage.—The sewerage of the district is, with one or two minor exceptions, of a makeshift and rudimentary character. At Kirkheaton the greater part of the sewage converges to an old rubble sewer, passes thence into a pipe sewer, from that through a channel in the rock, thence again into a pipe sewer, next flows in a channel on the surface, then again passes into a pipe sewer, and finally discharges into Kirk Ings Beck without any kind of treatment whatever. In addition to conveying the major portion of the slop drainage of the village, this so-called main sewer receives the drainage from a mill, where 300 workpeople are employed, and where are provided 21 waterclosets, five of which discharge directly into the sewer, and sixteen into a cesspool having overflow thereto. The outfall above referred to is situate about 300 yards above a small cluster of houses called Bottoms. The inhabitants of these houses complain very much of the loathsome, stinking condition of the beck, which passes immediately under their windows. And this nuisance is stated to be much intensified during periods of drought. A number of houses on the east side of Kirkheaton drain into a sewer, partly rubble, partly pipe, the sewage delivered by which is said to lose itself somewhere in a fissure of the rock. These rudimentary sewers are unprovided with any proper means for inspection, ventilation, or flushing.

At Upper Heaton and at Houses the old rubble drains have recently been replaced by pipes having outfalls on land. At Colne Bridge the sewage is partly conveyed in pipe and partly in rubble drains direct into the River Colne. These sewers, like those at Kirkheaton, are unprovided with any means for inspection, ventilation, or flushing. In the remaining portions of the district the slop-water is, as a rule, directed into rubble drains, having outfalls either on land or into the nearest watercourse. Sewers are frequently too superficially placed to drain cellars, and these in consequence are liable to become flooded.

The house drains are very generally constructed of rubble, although during the last year or two pipes have in a number of instances been substituted. The sink-pipes have in a considerable number of instances, also during the last year or two, been "disconnected" from the drains

and made to discharge over trapped gulley gratings. This disconnection has, however, frequently been done in such a slovenly manner as to allow slops to soak into walls and foundations.

Excrement and Refuse Disposal.—Excrement and ashes are almost universally disposed of in privy middens, the majority of which are of very large size. The privy is almost invariably so placed with regard to the midden as to prevent admixture of ashes with the excrement. The middens are sunk below the level of the surface, and so allow the soakage of ground-water into them. In many cases, these middens, especially those belonging to old houses, are uncovered, and of many their walls are dilapidated. In some cases faulty middens are situate in dangerous proximity to dwellings; for instance, at a house occupied by a registered milk dealer at Padanaram, there is an uncovered privy midden, containing, at the time of my visit, a quantity of liquid filth, and abutting on the wall of the dwelling. At this dairy the milk is kept in the cellar. At Colne Bridge some of the houses are provided with privies which discharge, by means of shoots, directly into the river, though other privies here have been furnished with tubs. And there remain houses where the excrement is still disposed of in uncovered middens with ruinous walls, situate near to dwellings. At Upper Heaton one midden was noticed which had the following dimensions: 8 ft. 6 ins. long, 6 ft. wide, 9 ft. 6 ins. high, the bottom of the midden being six or more inches below the ground level. Some houses in the same hamlet are unprovided with any privies at all. In the case of some new houses at Kirkheaton, structures adjoining the back doors of the houses, originally intended for waterclosets, have, in consequence of objections raised by the Local Board, been converted into privies. In Beaumont Square, where formerly the privy accommodation was very deficient, a block of privies has recently been built as a speculation, and these are let out to the occupiers of the houses in the neighbourhood at a small rental. These privies, which form a remarkable contrast to the rest of those in the district, are provided with receptacles of comparatively small size, and are furnished with seats which lift on hinges to allow of ashes being applied directly to the excrement. Further they are regularly scavenged. The scavenging of the middens, with the above exception, is carried out by occupiers who have to make their own arrangements with the farmers, and as a consequence accumulations of filth are common. Numbers of the receptacles, at the time of my visit, were quite full, ashes and other refuse were littered about them, and commonly heaps of refuse were to be seen in the neighbourhood of houses. In addition to the waterclosets at the mill already referred to, a few detached houses are also furnished with waterclosets, but in all instances these are said to drain into cesspools. At Colne Bridge and Bottoms the river and beck respectively are used as places of deposit for ashes, house refuse, and other filth by the inhabitants of houses on the banks. The beds of these streams are in consequence in a very foul condition.

Slaughter-Houses.—There are four slaughter-houses in the district, which are said to be inspected from time to time by the inspector of nuisances. They are not registered, and the slaughter house byelaws (which were allowed in 1864) with respect to removal of filth and to general cleanliness, do not appear to have been enforced. One of the slaughter-houses visited was dirty and contained a quantity of offal which had evidently been there some time. Such matter is, as a rule, disposed of in the nearest midden, and much of the blood and washings from the slaughter-houses find their way into the faulty sewers of the district.

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Cowsheds, Dairies, and Milkshops.—It is stated that there are 51 cowsheds, 13 milkshops, and one dairy in the district. These are registered, and are said to be under the inspection of the Nuisance Inspector, who is paid a special salary of 3*l.* per annum for this duty. The Sanitary Authority have not, however, hitherto drawn up regulations with regard to these matters, and some of the cowsheds which I inspected were apparently overcrowded.

There are said to be no common lodging-houses or bakehouses in the district.

Mortality Statistics.—In Table II. the mortality statistics for the Kirkheaton Urban Sanitary District are given for the 14 years 1877–90.

TABLE II.—MORTALITY STATISTICS for the KIRKHEATON URBAN SANITARY DISTRICT (Mean Population 2,690) for the period 1877–1890.

Year.	Births registered.	Deaths from all causes.	Deaths from									Deaths from Diseases in Cols. 4–12.	Deaths from Phthisis.	Deaths from Respiratory Diseases.	Deaths of Infants under one year of age.
			Small-pox.	Measles.	Scarlatina.	Diphtheria.	Whooping Cough.	"Fever."			Diarrhœa and Dysentery.				
								Typhus.	Enteric.	Other.					
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
1877 - -	83	51	—	—	1	—	1	1	—	—	—	3	4	11	12
1878 - -	101	46	—	1	1	—	—	—	2	1	3	8	9	7	8
1879 - -	77	59	—	1	3	—	2	—	2	1	—	9	4	12	10
1880 - -	76	39	—	2	—	—	—	—	—	1	—	3	7	12	6
1881 - -	89	47	—	—	—	—	1	—	3	—	—	4	5	11	10
1882 - -	85	61	—	—	4	—	1	—	—	—	—	5	5	7	11
1883 - -	70	43	—	—	—	—	—	—	1	—	—	1	5	9	9
1884 - -	76	38	—	—	—	—	1	—	—	—	1	2	8	7	11
1885 - -	74	43	—	1	—	—	5	—	—	1	—	7	4	10	10
1886 - -	62	41	—	—	—	—	—	—	—	—	1	1	7	7	7
1887 - -	63	43	—	—	4	—	—	—	—	—	—	4	6	7	9
1888 - -	71	57	—	—	—	—	2	—	—	—	1	3	4	8	13
1889 - -	52	58	—	3	—	1	—	—	—	—	—	4	4	12	13
1890 - -	57	43	—	—	—	—	—	—	—	—	—	—	4	9	5
Totals for 14 years, 1877–90 - -	1,036	669	—	8	13	1	13	1	8	4	6	54	76	129	134
	27·5	*17·7*	—	*2·1*	*3·4*	*0·3*	*3·4*	*0·3*	*2·1*	*1·1*	*1·6*	*1·4*	*2·0*	*3·4*	*129*
	Rates annually per 1,000 of the population.		*Rates annually per 10,000 of the population.*									*Rates annually per 1,000 of the population.*			*Per 1,000 Births.*

From the above table it will be seen that the mean mortality for the 14 years 1877–90, from all causes, has been at the rate of 17·7 per 1,000 living, whilst that of children under one year of age has been at the rate

of 129 per 1,000 births. From infectious diseases the chief mortality has been from scarlatina, whooping-cough, and "fever"; the deaths from each of these diseases being equal in number, and giving a rate annually in each case of 3·4 per 10,000 of the population. The actual number of fatal cases of "fever," which was chiefly enteric fever, has not been large, still they have been considerably more abundant than was to be looked for in a semi-rural district such as Kirkheaton.

(B)—Sanitary Administration.

The Local Government Act was adopted in Kirkheaton in 1862. The district has consequently now (1891) possessed local self-government for a period of close upon thirty years. The Local Board consists of nine members.

The Medical Officer of Health (Mr. William Thomas Smith, M.R.C.S.) has held the appointment since 1875. He is in private practice at Kirkheaton, and holds also the appointment of Medical Officer of Health in the Lepton Urban Sanitary District. He receives, as regards Kirkheaton, a salary of 15*l.* per annum, no part of which is repaid from public funds. He has acquired a thorough knowledge of his district, and has apparently devoted a considerable amount of time to its systematic inspection. But owing possibly to the multiplicity of nuisances in the district, the advice rendered by him to the Sanitary Authority has referred too exclusively to abatement of minor sanitary defects, and has not been extended to larger measures for the permanent improvement of the district.

The Inspector of Nuisances (Mr. W. M. Drake), who was in office at the time of my inspection, received an annual salary of 5*l.* as Inspector of Nuisances, 3*l.* as Inspector of Dairies, Cowsheds, and Milkshops, and 4*l.* as Assistant Surveyor; and was paid also a percentage on the rates collected. His appointment has since been terminated. During the last four years he has apparently been fairly active, but the measure of success which attended his efforts during the earlier of these years was not very encouraging to him.

In Table III. a statement is given of the number and nature of the nuisances reported to the Sanitary Authority during each of the four years 1887–90, together with in each instance the number remedied, and the number with regard to which no action was taken during the year.

From this table it will be seen that,—of 684 nuisances reported in 1887, only 208, or 30 per cent., were abated; of 263 nuisances reported in 1888, 214 (including a number which had been also reported in 1887), or 81 per cent., were abated; of 137 nuisances reported in 1889, 64, or 47 per cent., were abated; and that of a total of 182 nuisances in 1890, 150 (including all standing over from the previous year), or 82 per cent., were reported to have been abated before the end of that year. The increased activity of the Local Board in this respect in 1890 was no doubt directly due to the pressure exerted by the Local Government Board. In addition to the nuisances referred to in Table III., it appears from the Annual Report of the Medical Officer of Health for 1887, that the water supply to 14 groups of houses was then deficient; and from the same report it also appears that during that year 14 houses received a supply from the Huddersfield Corporation. In the Annual Report for 1888 a further batch of 14 houses was recorded as supplied from the Huddersfield water mains. In 1889, two, and in 1890, two additional cases of defective water supply were reported by the Medical Officer of Health. Of these three were remedied during 1890.

TABLE III.—STATEMENT showing:—(*a*) Number and Nature of NUISANCES reported to the KIRKHEATON URBAN SANITARY AUTHORITY during each of the four years 1887–90; (*b*) Number remedied; and (*c*) Number in which no action was taken.

Nature of Nuisance.	1887.			1888.			1889.			1890.				
	Number reported.	Number remedied.	*Number in which no Action was taken.*	Number reported.	Number remedied.	*Number in which no Action was taken.*	Number reported.	Number remedied.	*Number in which no Action was taken.*	Brought from Year 1889.	Nuisances reported during 1890.	Total.	Total remedied.	*Total in which no Action was taken.*
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
Sinks either unpiped, untrapped, or directly connected with drains	537	156	*381*	214	156	*58*	64	36	*28*	28	36	64	49	*15*
Other untrapped house drains							44	16	*28*	48	76	68	8	*8*
Choked drains	—	—	—	—	—	—	2	2	—	3	3	3	—	—
Flooded cellars	—	—	—	—	—	—	2	—	2	2	1	3	3	—
Insufficient privy accommodation	58	12	*37*	17	27	—	6	6	—	—	4	4	4	—
Defective privy accommodation		9			7									
Uncovered and improperly constructed ashpits	51	17	*34*	12	14	—	5	1	*4*	4	7	11	5	*6*
Defective urinals	—	—	—	—	—	—	—	—	—	—	—	2	2	—
Houses with defective eavespouts	18	—	*18*	13	7	*6*	7	1	*6*	6	—	6	6	—
Houses dilapidated							3	—	*3*	3	1	4	2	*2*
Houses with insufficient ventilation							—	—	—	—	3	3	3	—
Houses totally unfit for habitation							2	1	*1*	1	—	1	1	—
Overcrowded houses	10	6	*4*	3	2	*1*	2	1	*1*	1	—	1	1	—
Filthy houses	4	4	—	—	—	—	—	—	—	—	—	—	—	—
Filthy farmyards	—	—	—	—	—	—	—	—	—	—	4	4	3	*1*
Accumulations of manure	4	4	—	1	1	—	—	—	—	—	—	—	—	—
Public wells fouled	2	—	*2*	3	—	*3*	—	—	—	—	—	—	—	—
Totals	684	208	*476*	263	214	*68*	137	64	*73*	73	109	182	150	*32*

For road purposes, a working surveyor at a weekly wage of twenty-two shillings is employed.

There are no means in the district for securing the isolation of persons suffering from infectious disease, nor for the efficient disinfection of clothing, bedding, &c.

The Sanitary Authority have not, as yet, adopted the Infectious Disease (Notification) Act, 1889, nor any portion of either the Infectious Disease (Prevention) Act, 1890, or the Public Health Acts Amendment Act, 1890.

The Sanitary Authority have not considered it necessary to put the Canal Boats Act in force, as there is no wharf in the district.

They possess a code of byelaws with respect to:—

(*a.*) Streets and new buildings,
(*b.*) Slaughter-houses,
(*c.*) Common lodging-houses,
(*d.*) Nuisances.

The byelaws with regard to new streets and buildings are extremely indefinite in what they prescribe, as well as very deficient in numerous respects. Moreover they are very one-sided since the Local Board may practically demand what they choose, regardless of whether it is necessary or proper; the form of the byelaw being such as in effect to deprive the person aggrieved of obtaining an appeal or hearing on the merits of any particular case of alleged infraction. As examples of the deficiencies of this code of byelaws, I may refer to the fact that regulations with respect to:—space in front or in rear of houses; construction of foundations; provision of damp course; thickness of walls; flues; ventilation of houses; ventilation of drainage; disconnection of house wastes, &c., are wholly wanting. Moreover, the actual regulations with regard to the construction of privies, ashpits, &c., are so deficient as to be practically useless.

These byelaws, which were sanctioned by the Home Office in 1864, are very much out of date; and the Sanitary Authority, at length recognising this fact, submitted last year amended byelaws in the several subject-matters for approval by the Board.

In Table IV. a complete statement is given of the expenditure year by year of the Kirkheaton Local Board during the ten years March 25th, 1880, to March 25th, 1890.

From this table—supplied to me by the clerk to the Urban Sanitary Authority, and which has not been checked officially—it will be seen that the total expenditure of the Kirkheaton Local Board during the 10 years ending March 1890 has amounted to 7,839*l.* 10*s.* 2½*d.*; and that of this sum 6,991*l.* 18*s.* 1*d.* is stated to have been expended in the maintenance of roads, 115*l.* 3*s.* 5½*d.* in legal and election expenses, 576*l.* 15*s.* 3*d.* in salaries and other establishment charges, and 153*l.* 9*s.* 7*d.* on matters connected with the school attendance committee; whilst 2*l.* 3*s.* 10*d.* only has been expended on nuisance removal.

A certain amount of expenditure has been incurred in the substitution of pipes for rubble drains both in Kirkheaton proper and in the outlying hamlets; expenditure which does not appear separately in the statement. This is due, I understand, to the fact that the cost of this work has always been included in the Local Board's accounts under "Repairs of Roads."

The Kirkheaton district was inspected by Dr. Gresswell in February 1887 in connection with the Board's Cholera Survey, and he at that time drew the attention of the Sanitary Authority to the various unwholesome conditions likely to affect the public health of the district. After his inspection he submitted a memorandum (*see* Addendum B.) for the guidance of the Sanitary Authority as to the measures necessary to

Table IV.—Statement of Expenditure by the Kirkheaton Local Board for the Ten Years ending 25th March 1890.

Details of Expenditure	1880-81.	1881-82.	1882-83.	1883-84.	1884-85.	1885-86.	1886-87.	1887-88.	1888-89.	1889-90.	Total (10 Years).
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Sewerage works	—	—	—	—	—	—	—	—	—	—	—
Sewage disposal works	—	—	—	—	—	—	—	—	—	—	—
Street improvements	—	—	—	—	—	—	—	—	—	—	—
Highways :—											
Repairs of main roads	—	—	—	—	—	—	—	—	—	—	—
Repairs of other roads	457 6 4½	685 15 6	540 7 4	566 12 1	566 14 9	797 11 10	833 15 5½	1,297 13 11	530 10 2	715 10 8	6,991 18 1
Other payments	—	—	—	—	—	—	—	—	—	—	—
Waterworks	—	—	—	—	—	—	—	—	—	—	—
Gasworks	—	—	—	—	—	—	—	—	—	—	—
Public lighting	—	—	—	—	—	—	—	—	—	—	—
Markets	—	—	—	—	—	—	—	—	—	—	—
Baths and washhouses	—	—	—	—	—	—	—	—	—	—	—
Slaughter-houses	—	—	—	—	—	—	—	—	—	—	—
Hospital	—	—	—	—	—	—	—	—	—	—	—
Cemetery	—	—	—	—	—	—	—	—	—	—	—
Public offices	—	—	—	—	—	—	—	—	—	—	—
Other public works or purposes, viz. :—											
(1.) Scavenging	—	—	—	—	—	—	—	—	—	—	—
(2.) Nuisance removal	—	—	—	—	0 9 10	0 17 0	—	0 17 0	—	—	2 3 10
(3.) Miscellaneous	—	—	—	—	—	—	—	—	—	—	—
Private improvement works	—	—	—	—	—	—	—	—	—	—	—
Works of private street improvement	—	—	—	—	—	—	—	—	—	—	—
Other private improvement works	—	—	—	—	—	—	—	—	—	—	—
Election expenses	2 15 10	3 10 0	6 5 2	4 11 0	7 0 3	7 0 10	6 1 9½	0 12 6	3 7 6	3 3 9	44 8 7½
Legal expenses	0 6 8	—	—	—	1 18 2	6 10 5	—	26 6 8	34 12 4	1 0 7	70 14 10
Salaries not previously included :—											
Clerk				10 8 6	7 17 6	10 0 0	12 0 0	12 0 0	12 0 0	12 0 0	
Treasurer				—	—	—	—	—	—	—	
Medical Officer of Health				10 0 0	10 0 0	10 0 0	—	20 0 0	15 0 0	15 0 0	
Inspector of Nuisances	55 4 2	44 19 6	59 3 4	5 0 0	—	—	—	—	5 0 0	5 0 0	524 8 3
Surveyor				—	—	—	—	—	—	—	
Collector				20 0 0	26 14 3	27 16 0	22 15 0	42 0 0	20 0 0	20 0 0	
Other officers				—	—	—	—	—	7 0 0	7 0 0	
Establishment charges not before included	14 8 0	8 14 4	29 4 8	—	—	—	—	—	—	—	52 7 0
Expenses of School Attendance Committee	—	—	—	13 12 10	16 12 1	25 7 0	25 19 9	35 8 6	15 14 0	20 15 5	153 9 7
Other payments	—	—	—	—	—	—	—	—	—	—	—
Total expenditure	530 11 0½	742 19 4	635 0 6	630 4 5	637 6 10	885 3 1	900 12 0	1,434 18 7	643 4 0	799 10 5	7,839 10 2½

be taken to remedy the defective conditions observed by him. In Table V. a summary is given in parallel columns of the chief facts with regard to the sanitary circumstances and administration of the Kirkheaton district observed—(*a*) during Dr. Gresswell's inspection in 1887 (as recorded on pp. 174–177 of the Supplement to the Board's Annual Report for 1886–87), and (*b*) during my recent inspection. From a consideration of the table a judgment may be formed of the progress made in the district during the last four years.

Table V.—Summary of Facts observed as to the Sanitary Circumstances and Administration of the Kirkheaton Urban Sanitary District during inspections made in 1887 and 1891 respectively :—

——	1887.	1891.
Cleanliness of roadways and domestic premises.	Bad. Befouled with refuse and sewage.	Improved. Still bad about Colne Bridge.
Sewerage and drainage.	Sewering and house drainage very old and defective.	Some lengths of rubble drains replaced by pipes, otherwise the same.
	Abundant opportunities for entrance of drain air into dwellings. Cellars wet and undrained.	House sinks now generally disconnected.
	Sewage nuisances.	The same.
Excrement disposal and removal.	Midden privies of bad construction, and inconveniently situated.	The same.
	Insufficient privy accommodation.	The same.
Refuse removal -	Great negligence. Heaps of refuse about the ashpits and premises generally.	The same.
Water supply -	In part (less than half the houses) public supply satisfactory. To remainder of houses very defective, from sources open to various forms of pollution.	More than half the houses supplied from Huddersfield Corporation Works. Remainder practically as in 1887.
Sanitary condition of dwellings of poor.	Ill-ventilated and unclean, sometimes grossly so. Some back-to-back or back-to-earth. Some semi-courts grossly filthy.	The same.
Crowding of dwellings on area.	None.	None.
Overcrowding of dwellings.	Excessive, not dealt with.	None observed.
Administration by Sanitary Authority.	Almost at a standstill, and this in face of many urgent requirements.	The same as regards comprehensive work of a permanent character.
Work of Medical Officer of Health.	Unsatisfactory.	Now fairly satisfactory; but much of work done is such as should properly be done by Inspector of Nuisances.
Work of Inspector of Nuisances.	Some work done among the gross nuisances. (Salary 5*l.* per annum.)	The same.
Abatement and prevention of nuisances.	Very weak.	Improved.
Hospital provision -	None.	None.
Disinfecting apparatus.	None.	None.

App. A. No. 6.

On the Kirkheaton U.S.D.; by Dr. Barry.

As a result of this inquiry it is evident that 29 to 30 years' jurisdiction by the Local Board of Kirkheaton has been of little profit to the district. They have indeed attended to the condition of the roads, and have during the last three or four years procured the abatement of some of the grosser nuisances; and in addition they have recently undertaken revision of their byelaws. But as regards the important matters of sewerage and sewage disposal; excrement and refuse disposal and removal; regulation of new buildings, of slaughter-houses, of cowsheds, dairies, and milkshops; and as regards the isolation of infectious disease,—little or nothing has yet been effected by this Sanitary Authority.

ADDENDUM A.

Annual Report of the Medical Officer of Health for the Year 1889.

To the Kirkheaton Sanitary Authority and County Council.

Gentlemen,

I once more beg leave to present my Annual Report. In your district, during the 12 months ending 31st December 1889 there were registered 52 births, 29 males and 23 females, being a birth-rate of 18·15 per 1,000 per annum of the population of your district, and 58 deaths, 34 males and 24 females, being a death-rate of 20·25 per 1,000. Of the deaths there were 20 old people, 7 of whom were 60 years old, 9 over 70, and 4 over 80 years old, and 19 young children, all under 2 years old, 12 of whom were under 1 year old. Deaths from zymotic or infectious diseases were five in number, viz., 3 from measles, 1 from diarrhœa, and 1 from diphtheria—a death-rate of 1·74 per 1,000. All the houses where the measles took place were in a satisfactory sanitary condition. The death from diarrhœa in a child only 4 months old, I think, can scarcely be included in this class of disease. The death from diphtheria was supposed to have been caused by an imperfectly trapped sink, which I ordered to be remedied at once by being trapped in a more efficient manner. All the rest of the deaths occurred from ordinary and unavoidable causes, over which we have little or no control, such as old age, bronchitis, pneumonia, &c.

The sanitary work during the year (as in the previous 12 months) consisted in endeavouring to carry out Dr. Gresswell's recommendations as much as possible, viz., having all sinks properly piped, trapped, and disconnected. All slop drains piped and trapped; all privies and ashpits properly constructed; overcrowded houses attended to, &c., and a proper supply of pure water in different parts of the district where needed. During the greater part of the 10 days which I spent in visiting and inspecting the district, going from house to house, I met with numerous insanitary matters which I brought before your notice at different times during the year, and though some of them have been remedied, I regret to say a great part of them yet remain undone.

On another page will be found a tabulated statement showing the insanitary matters that I have brought before the notice of the Sanitary Authority and (as I am informed by the Sanitary Inspector) those that have been remedied during the year.

The health of your district I consider to be fairly satisfactory.

(Signed) W. T. Smith,
Medical Officer of Health.

A Tabulated Statement for the year ending 31st December 1889 of Cases Reported and Remedied.

	Cases Reported.	Cases Remedied.
Sinks unpiped, untrapped, and otherwise defective	64	36
Slop drains unpiped and untrapped	44	16
Drains choked up	2	2
Deficient privy accommodation	6	6
Dilapidated privies and ashpits	5	1
Houses with defective spouting	7	1
Houses with dilapidated or leaky roofs	3	0
Houses with flooded cellars	2	0
Houses overcrowded	2	1
Defective water supply	2	0
Houses not fit for occupation	2	1
	139	64

(Signed) W. T. Smith,
Medical Officer of Health.

ADDENDUM B.

Memorandum of Measures recommended by Dr. Gresswell, after his Inspection in 1887, for the Sanitary Improvement of the Kirkheaton Urban Sanitary District.

1. The Sanitary Authority should make arrangements whereby the removal of excrement and refuse may be carried out in such a systematic manner as to secure the emptying of every filth receptacle at short intervals, which should not exceed one week. This will be most satisfactorily accomplished if the Authority themselves undertake the work under section 42 of the Public Health Act, 1875, for the populous portions of the district, scavenging in outlying parts being imposed upon occupiers under section 44 of the same Act.

2. The Sanitary Authority should see that nuisances arising from insufficiency, from faulty situation, or from defective construction of filth receptacles, are effectually abated. They should see that the provisions of section 36 of the Public Health Act, 1875, are strictly carried into effect, and should cause all necessary structural alterations in filth receptacles to be made. The introduction of waterclosets or of some form of the improved "dry systems" should be carefully considered, and if fixed receptacles for filth be still retained in use, they should be reduced to the smallest practicable dimensions, and they should be so constructed as to be watertight, and (by raising their floors to at least 3 ins. above the ground level and by roofing them over) to keep out all unnecessary nuisances they should afford ready means for the mingling of dry ashes with the excrement day by day, and also for scavenging.

3. The Sanitary Authority should provide proper sewers for all populous parts of the district. Sewers which allow leakage of contents or lodgment of sediment should no longer be used for the conduction of sewage. The pollution of watercourses by sewage should be discontinued, and means for innocuous disposal of sewage should be provided.

4. The condition of house drainage should be placed upon a thoroughly satisfactory footing, and the provisions of the model byelaws relating to house drainage should as far as practicable be carried out.

5. Active steps should be taken to prevent the further use of unwholesome water for domestic purposes, and to secure for each dwelling an adequate supply of wholesome water within a reasonable distance. To

this end the Sanitary Authority should instruct their Medical Officer of Health to report in detail upon the wholesomeness, sufficiency, and accessibility of the water supply to all houses.

6. Where dwelling-houses are in such a condition as to be sources of nuisance or of danger to health, steps should be taken to have them closed until they have been rendered fit for habitation.

To prevent dampness, proper channels for conveying away roof and surface water, and where necessary, subsoil drainage, should be provided. Windows of inhabited rooms should be made to open to an adequate extent, cleansing and limewashing of the interior of houses should be enforced where required, and overcrowding should be actively dealt with.

7. The Authority should see that premises are kept in a wholesome condition. To his end premises should be levelled, paved, and properly sloped to drain inlets, and the keeping of animals so as to cause nuisance should be promptly put a stop to.

8. The Authority should procure a revision of the byelaws at present in force in the district on the basis of the model code, and in the meantime these byelaws should be fully enforced, attention being specially directed to the condition and management of slaughter-houses.

9. The duties of the Inspector of Nuisances should be defined, and in making such definition those duties should be specified which are laid down in the Local Government Board's Order of March 10th, 1880, and a salary commensurate with the systematic full and efficient performance of these duties should be attached to his office.

10. The Authority should consider the advisability of combining with neighbouring Sanitary Authorities with a view of making a joint appointment to the office of Medical Officer of Health and also to the office of Inspector of Nuisances.

11. The Sanitary Authority should make arrangements whereby they may be enabled to fully carry out their powers for averting the spread of infectious disease.

(*a.*) They should make arrangements with the Registrar of Deaths so that the Medical Officer of Health may be supplied with a regular weekly list of deaths and with prompt information upon registration of deaths from zymotic disease, and application should be made to the Guardians of the Huddersfield Union for regular weekly list of pauper sickness in the district.

(*b.*) They should provide accommodation of the nature of a hospital for the isolation of persons who, while suffering from infectious disease, cannot be treated without danger to themselves or to others at their own homes. It is essential to the usefulness of such an establishment that it should be kept in readiness so as to be available for the earliest cases of infectious disease which may occur, in order that by the isolation of such cases the extension of the disease may be prevented.

In considering this matter of hospital accommodation, the Authority should make reference to the Office Report on the Use and Influence of Hospitals for Infectious Diseases in the Supplement by the Medical Officer to the Tenth Annual Report of the Local Government Board, and to the plans herewith forwarded of hospitals for infectious disease.

(*c.*) Provision should also be made for the efficient disinfection of infected houses and their belongings. Infected articles of clothing and bedding which cannot be washed should be systematically disinfected by heat, and an efficient apparatus for this purpose should be provided. Full information on this subject will be found in the Office Report on Disinfection by Heat in the supplement by the Medical Officer to the Fourteenth Annual Report of the Local Government Board.

(*d.*) Joint action with neighbouring Authorities in providing means for isolation and disinfection should engage careful consideration.

[12. *Special recommendation with respect to steps to be taken in the event of the importation of cholera, not reproduced.*]

No. 7.

Report on a Prevalence, in certain Localities of Northamptonshire, of Anomalous Illnesses, characterised by Pneumonia, and sometimes by Meningeal Symptoms, and frequently associated with Tonsilitis or Sore Throat; by Dr. Bruce Low.

The chief of the outbreaks or illness with which this report deals came first under the notice of the Board at the end of February through a newspaper paragraph as follows: "An alarming outbreak of pneumonia "is raging among the children in Raunds, a shoe manufacturing village "in Northamptonshire. Scarcely any under six years of age have "escaped, and from 60 to 70 serious cases have occurred. Three "deaths have already taken place. The epidemic shows no signs of "abatement."

Hereupon (early in March) the Board wrote to the Thrapston Rural Sanitary Authority, in whose district Raunds is situated, drawing attention to the above paragraph and requesting a report by the Medical Officer of Health on the subject.

On March 11th a preliminary report, confirming in general terms the above statements, having been received by the Board from the Medical Officer of Health, this inquiry was ordered, and I was directed to make it.

On arriving in the district I set to work, by help of the local medical practitioners, the officials of the Sanitary Authority, and others, to learn as precisely as possible the amount and nature of the illness that had been current, its distribution in place and time, and the conditions under which it had occurred. At that date (the end of March) the malady coming in question had, so far as was known, been limited to Raunds. Accordingly, and with a view to letting slip no opportunity of obtaining clues to the causation of the outbreak, I began, *pari passu* with my inquiries about sickness, to take account of a variety of circumstances that might have a bearing on the subject, and thus collected a quantity of data relating to geology,* meteorology,† food and water supplies, school attendance, and the like. I gave particular attention also to the sanitary circumstances of Raunds, which place I found in a flagrantly unwholesome condition. But meanwhile I learned, by the courtesy of a medical man (Mr. Fuller of Bugbrooke) resident some 20 miles south-west of Raunds, of a nearly coincident outbreak of similar illness at

* For valuable information on the Geology of Raunds, I am indebted to Mr. G. Lee, the Wesleyan schoolmaster.

† For very useful meteorological data I have to thank the Rev. R. S. Baker, Hargrave Rectory, W. Law, Esq., Northampton, and C. A. Markham, Esq., Sedgebrook, Pitsford.

Heyford in the Northampton Rural Sanitary District; and upon communicating on the subject with a number of medical practitioners elsewhere in the county, I obtained information of even earlier prevalence of what seemed without doubt to have been a like malady in Kettering and in Northampton districts. So that it came to be seen that whatever the insalubrity of Raunds, and the influence of unwholesome conditions there on the severity or fatality of attacks among its inhabitants, the question of the *origin* of the prevalent illness could not usefully be studied in this place. Nor, for reasons that will presently be manifest, was it found profitable to study, very profoundly, questions as to means of dissemination of the malady or maladies current here and elsewhere in Northamptonshire.

Accordingly in what follows I have almost nothing to say as to causation, and deal incidentally only with methods of spread; having had to content myself with, in the main, recording its symptoms and its behaviour in one and another place.

The influence of sanitary circumstances (which I may here state were dissimilar at Raunds and Heyford) upon spread or upon the quantity of the current malady, I cannot, with my present knowledge of the subject, attempt to measure; so I refer to them in this report in brief terms only. Nevertheless, having in the course of my inquiries obtained suspicion that the very abundant unwholesome conditions in Raunds may very well have operated to enhance the severity and fatality of any illness introduced or set agoing there, I have deemed it proper to give in a separate report a detailed account of the sanitary condition of the place, and of administration by the Thrapston Rural Sanitary Authority.

I proceed now to record the facts ascertained by me respecting the sickness that has been recently prevalent in Raunds and in Heyford, along with the additional information as to like illness which has come from Kettering and Northampton.

Raunds in the Thrapston Rural Sanitary District.

From my separate report I select some few particulars concerning the parish of Raunds. It has an estimated population of 3,350 persons, most of whom reside in Raunds village, and are employed (many of them at their own homes) in the shoemaking industry. The village, situated in a shallow valley of Great Oolite, consists chiefly of a single long straggling street with several short streets. Parts of the village are somewhat closely built, so that dwellings have little open space about them; but most cottages have gardens or at least a back yard, though the latter has been sometimes reduced in dimensions by the erection in it of a small workshop. Nearly parallel to the main street is a small and shallow brook which joins the River Nene about two miles below the village. Into this brook is discharged most of the liquid refuse of the place by way of channels and drains of various sorts. There are no sewers properly so-called. Excrement disposal is mainly by old-fashioned privies, partly by pail-closets which have been recently introduced. The few waterclosets of the place discharge directly into the brook, or indirectly by way of cesspools, which have overflow thereto.

Water supply is from private pumps or draw-wells situated near to dwellings. In addition there are four public pump wells in the main street, under the care of the Sanitary Authority.

On visiting Raunds I found that the epidemic which was in question had subsided; no new cases indeed had occurred since the middle of March, and thus the opportunity was not afforded me of studying the malady in its pathological aspects. The place, I was told, had suffered severely a year ago from influenza when that malady was epidemic in this part of England; and local opinion, medical and other, was very strongly to the effect that the illness that had recently prevailed was wholly different from the influenza with which Raunds people were acquainted.

By the help of Dr. Mackenzie* and of his assistant Dr. Ettles (the only two resident medical men in Raunds, and to whom I owe many thanks for much valuable help in the investigation), as well as by inquiry among families attacked by the current illness, respecting neighbours who had been attacked also, a list was got together of 93 invaded households, a number which probably included the bulk of those that suffered conspicuous illness. And on personal inquiry at these houses, I obtained information of 155 persons, almost wholly young children and babies, who had been attacked by "pneumonia," and of 104 others, children and adults for the most part, who had suffered about the same time from indefinite malady, mostly designated tonsilitis or sorethroat. So far as the graver illness, that medically designated "pneumonia," is concerned, the symptoms as ascertained from mothers and doctors had been as follows:—

The malady always began with vomiting and great drowsiness, occasionally there was a convulsion. Then followed hot skin, flushed face, and hurried breathing (with rapid movement of the alæ nasi), accompanied by cough. Sometimes there were fits of screaming, sometimes there was squinting. Some children had herpes of the lips, a few had jaundice, and in about a third of the attacks there was diarrhœa, usually at the commencement of the illness. Some patients developed purulent discharge from one or both ears. In children over the age of three or four years an early and distinct rigor was often observed, and the child complained at first of its throat and head, and afterwards of a pain in the side. On examination of the throat nothing more than some redness could be seen. In most cases there was soon great prostration of strength, and often, later on, emaciation. The onset was always sudden. Recovery, when it had commenced, was rapid. In the majority of cases the acute illness terminated by a profuse and critical sweat, sometimes also with epistaxis.

The temperature at first averaged about 103°, in some severe cases it reached 105°, but on the second or third day it generally dropped down to 102°, and coincidently lung consolidation was usually made out. The temperature, I was told, remained, with slight variations, at about 102° during the remainder of the acute portion of the illness. The average duration of the disease was from 10 to 12 days, but some of the mild cases lasted only five days or so. Symptoms consistent with meningitis,—such for instance as delirium, fits of screaming, squinting, retraction of the head, convulsions, and coma,—were observed, concurrently or in sequence, in particular cases. Enlargement of the parotid or swelling of the cervical glands was also noted.

Among the older children and adults of the families invaded there was, as has been said, concurrent prevalence of tonsilitis. This did not

* The medical practice at Raunds is almost wholly in club-practice, and therefore the medical men had to rely on their memories as to dates and cases, no entries in ledger or day-book having been made as a rule.

differ apparently from commonplace tonsilitis, and the mothers who nursed the sick children especially suffered from it.

As far back as December 1890 cases of this ailment involving lung complication had been observed, and antecedently, during November, there is said to have been a large number of cases of tonsilitis and "ulcerated throat."

During the earlier part of January there is no record of graver cases, but in the week ending January 17th a single house-invasion of "pneumonia" was noted, followed by another in the next week. In the week ending January 31st there were no fewer than eight families attacked by the severer malady, and in the next week the households invaded numbered 22. Afterwards, although the number of household invasions week by week was never again so large, the epidemic of graver illness continued in full swing, so to speak, till the end of the first week in March. During the week ending March 14th only two families were newly invaded, and in the following week only one. After this the outbreak seems to have subsided, and no further invasions are known to have occurred. The disease appears to have been fairly uniformly distributed through the village; no one part of it can be said to have had less of the ailment than other parts.

The following table shows the progress of the epidemic as marked by the number of households invaded, week by week, by illness of the sort classed as "Pneumonia."

Table I., showing Number of Households in Raunds invaded by "Pneumonia" from December 1890 to April 1891.

1890.	
Households invaded during week ending December 6th - - -	2
,, ,, ,, ,, ,, 13th - - -	4
,, ,, ,, ,, ,, 20th - - -	1
,, ,, ,, ,, ,, 27th - - -	2
1891.	
,, ,, ,, ,, January 3rd - - -	—
,, ,, ,, ,, ,, 10th - - -	—
,, ,, ,, ,, ,, 17th - - -	1
,, ,, ,, ,, ,, 24th - - -	1
,, ,, ,, ,, ,, 31st - - -	8
,, ,, ,, ,, February 7th - - -	22
,, ,, ,, ,, ,, 14th - - -	10
,, ,, ,, ,, ,, 21st - - -	13
,, ,, ,, ,, ,, 28th - - -	14
,, ,, ,, ,, March 7th - - -	12
,, ,, ,, ,, ,, 14th - - -	2
,, ,, ,, ,, ,, 21st - - -	1
,, ,, ,, ,, ,, 28th - - -	—
,, ,, ,, ,, April 4th - - -	—
,, ,, ,, ,, ,, 11th - - -	—
Of 670 households, total invaded from December 1890 to April 1891 -	93

The next table gives the number of families invaded in each month from December to April, with total cases and deaths from "Pneumonia" as well as the number of cases of tonsilitis in affected households.

Table II. showing for the Parish of Raunds the Number of Households invaded Month by Month by "Pneumonia," with the Total Cases in each Month thus attacked and the Deaths therefrom; and as well, the concurrent Cases of Tonsilitis and "Bad Throat," Month by Month, in the Families invaded by the "Pneumonia."

Months, 1890-91.	Households invaded by above-named Diseases.	Persons attacked by these Diseases, viz.:—	By "Pneumonia," (some also having Throat Affections).		By Throat Affections only: none fatal.
			Cases.	Of whom fatal.	
December - - -	9	34	19	—	15
January - - -	10	33	17	1	16
February - - -	59	155	97	4	58
March - - -	15	37	22	5	15
Four months -	93	259	155	10	104

As has been said, the graver illness showed a marked preference for young subjects, and with one exception the fatal cases were all under two years of age. Children under five years were usually the first sufferers in their families. In the following table will be found in different columns information as to age of first cases in families and the total number of cases at certain age-periods.

Table III. showing for the Parish of Raunds the First Cases in Families, the total Cases of "Pneumonia," and of Tonsilitis, and the "Pneumonia" Deaths, occurring during December, January, February, and March, distributed according to Age-periods.

Age-periods.	Pneumonia. First Attacks in Families.		Subsequent Cases. "Pneumonia."		Tonsilitis.	Total Cases of Illness of both Kinds.		Deaths from "Pneumonia."	
Under 1 year - -	12		11		—	23		3	
1 to 2 years - -	19		10		—	29		6	
2 to 3 „ - -	14	69	7	41	—	21	115	—	9
3 to 4 „ - -	18		5		2	25		—	
4 to 5 „ - -	6		8		3	17		—	
5 to 10 „ - -	22		14		14	50		—	
10 to 15 „ - -	1		5		16	22		1	
15 to 25 „ - -	1		2		5	8		—	
25 to 60 „ - -	—		—		62	62		—	
60 and upwards -	—		—		2	2		—	
Estimated population, 3,350.	93		62		104	259		10	

In several instances two children in a family became ill on the same day. In two houses the sufferers were twins, and each pair of twins

became ill on the same day. Multiple attacks in families were common. Out of the 93 households invaded, 49 had 1 case each, 32 had 2 cases, and 12 had 3 or more cases. As regards the 49 households with single attacks, it deserves to be noted that in 21 instances the sufferer was an only child.

In illustration of the behaviour of the current malady in one and another family, I take at random from my note-book facts I have recorded respecting three households invaded :—

I.—A. E., aged 18 months, the daughter of a shopkeeper, was suddenly taken ill on February 6th with vomiting and drowsiness, followed by cough, fever, flushing of the face, evident pain, difficulty in breathing, and diarrhœa. Consolidation at the base of one lung was made out on the second day. After remaining severely and dangerously ill for about 10 days the child underwent a profuse sweating and began to recover. Though much emaciated and prostrated, recovery was rapid. On February 20th her brother, aged 13, became suddenly ill with bilious vomiting, drowsiness, sorethroat, delirium, fever, cough, and constipation. The medical attendant says the case at first presented the physical signs of an "acute croupous pneumonia," but later the boy developed meningitis, of which he died on March 1st. Between the attack of the infant A. E. and that of her brother, the servant girl of the house had developed a "bad throat," and being unable to work had to leave her situation and go home.

II.—J. A., aged 3½ years, the son of a carpenter, was suddenly taken ill on February 9th. He had a distinct rigor, followed by vomiting and drowsiness. Also he complained of his head and throat, afterwards of his side. His breathing was short, and he had a cough, earache, fever, and flushed face. On the third day of the illness the base of one lung was discovered to be consolidated. When he had been ill about 10 days he underwent a profuse sweating, and began to recover. He had attended school the day he was taken ill. On February 13th his brother, aged 19 months, was attacked with very similar symptoms. He screamed a good deal, and his dyspnœa was great. He died on February 21st, after eight days' illness. The mother of these two children is stated to have had an ulcerated throat three weeks before the first child was taken ill. She was also feverish and had a cough while her two children were ill. The father too had a cough and some malaise at the same time.

III.—B. P., a girl aged 22 months, the daughter of a shoemaker, was taken ill on March 2nd, with vomiting, drowsiness, sorethroat, cough, abdominal pain, and diarrhœa. She soon had fever, with flushing of face, shortness of breath, and "rattling" in the chest. Having been ill 10 days, she developed a profuse sweating, and then began to improve. She was greatly emaciated. On March 6th her two sisters, age respectively 3 and 4 years, were both similarly attacked, and each, after an illness of a like duration, ending in a critical sweat, began to recover. Both had during convalescence a purulent discharge from their ears. The younger of these two (aged 3) had also some enlargement of the parotid on one side. All three children are delicate, and, the mother says, "subject to bronchitis." During the course of the children's illness both the father and the mother suffered from sorethoat and cough.

With reference to other points of interest it deserves to be noted that locally the malady was regarded as "catching," and the following facts appear to support the notion that the disease was communicable from person to person.

On February 13th a young married woman, with her infant, aged 12 months, and then in good health, came from Northampton to Raunds in consequence of the death (from consumption) of her brother, who had been living in the village with their widowed mother, who was thus left alone in her house. The funeral took place on February 14th. Of the family next door, two children were then suffering from the prevalent

"pneumonia." Many of the neighbours called at the widow's house on the 13th and 14th, but I could not ascertain that the grandchild had been taken into any of the adjoining houses where illness actually existed, though this is very probable. This infant (the grandchild) fell ill in Raunds on February 16th, and passed through a typical attack lasting 10 days. Its life was dispaired of, but it recovered. While this infant was ill a girl, aged 9, residing nearly two miles from the village, and coming daily to school in Raunds, spent regularly her dinner hour in the widow's cottage where the baby was ill, eating her midday meal there. She is not known to have suffered any illness. But at her home a baby, aged 11 months, which had never yet left the house, was taken ill of "pneumonia" on February 26th. This infant nearly lost its life, but eventually recovered; it had ear discharge and some enlargement of its cervical glands during convalescence. While it was ill the father developed a "very bad throat," and the mother says she had a "cold" too at the time. The mother goes out charing at a farmhouse close by. Here a boy, aged $2\frac{1}{2}$ years, began to be ill on March 3rd, with all the previously-described symptoms of the current complaint. On March 5th another child at the farmhouse, aged 1 year, began also to be ill. This infant had convulsions at first, and jaundice followed on his "pneumonia," but he recovered after an illness, lasting a month. The elder of these two boys had herpes of the lips, his illness lasted about 10 days. While these two children at the farmhouse were ill, the only other child in the family, a lad aged 11, had a bad sorethroat and a "cold." The father also had tonsilitis, and the grandmother, aged 55, had an attack of "pleurisy" on March 17th, lasting a fortnight, but she recovered. None of this family had been to Raunds for a considerable time previous to their illness, and no shopping was done by them there. The suggestion appears to be that the charwoman brought the illness from her cottage to the farm, after the schoolgirl had conveyed the disease there from the widow's house at Raunds. The girl herself (whose daily task it was to nurse her baby sister on returning from school) is not, as I have said, known to have suffered, but I found her with a very deeply congested throat and some swelling of the tonsils on April 7th. It is possible she had suffered slightly from the epidemic illness before the baby at home took the disease. This schoolgirl went daily to the farm for the milk for the cottage. The farmer's wife, however, stated that the girl never to her knowledge came inside the house; the milk was handed to her at the door.

Another example is the following:—

At a secluded "lodge" more than two miles from Raunds, there lives a farmer's hind, with wife and two children, aged respectively 13 months and $2\frac{1}{2}$ years. The house is set back some distance from the main road, and the woman says she rarely leaves home or receives visitors. The youngest child had a nævus on its head, and to obtain treatment for this nævus she took it (the other child accompanying her) to Raunds on March 9th. Dr. Mackenzie's waiting-room was crowded, and she had to wait some time to see the doctor. Neither before nor after her visit to the surgery on March 9th did she enter any other house in Raunds.

On March 13th the elder child began to be ill with vomiting, drowsiness, and diarrhœa, followed by fever, cough, "stuffing at the chest," flushing of the face, and a purulent discharge from the nostrils. Two days later the baby also began to be ill, and passed through a similar attack, lasting about two weeks. The suggestion here is that the disease was contracted in the doctor's surgery, during the time these

children waited there on March 9th. Dr. Mackenzie tells me that in the early stages of the prevalent ailment mothers often brought their children to the surgery, instead of sending for him to come to their homes, and it is probable that convalescents, or messengers from invaded households, were present at the surgery on the date mentioned (March 9th).

It should be added that both Drs. Mackenzie and Ettles considered the malady infectious, and regarded the average incubation period as being about four days.

With reference to the above considerations respecting possible personal infectiousness of individuals attacked, I tried to ascertain what influence, if any, school attendance had had on the epidemic. As to this, I was unable, having regard to the circumstance that some 50 per cent. of first sufferers in their families were not of age to attend school, to obtain any but negative evidence; if schools did as a matter of fact conduce to the epidemic, they could only have done so by means of minor illness, such for instance as tonsilitis and sorethroat, which has gone unrecorded. That, on the other hand, the epidemic itself had little effect on school attendance will be seen from Table A. at the end of this report.

A further circumstance of interest is, that during the course of the epidemic some of the children attacked developed a rash of some sort. In numerous instances the eruption was vesicular, chiefly on the chest and abdomen, and this was thought by some of the mothers to be like "chicken-pox," but by the medical men such rash was regarded as sudamina. In several cases there seems to have occurred a scarlatina-like rash, and though the symptoms accompanying it were precisely as in the other "pneumonia" cases, a suspicion was created in the doctors' minds that such cases were in reality scarlet fever, owing to the fact that desquamation followed the rash. No known cases of the latter disease apart from these, however, existed in the place at the time. During my inquiry I met with history of four of these quasi scarlatinal cases in different families. Two of them, in one of which only "peeling" existed without observed rash, occurred as far back as October 1890, and have not been included in the tables relating to the epidemic cases, although I cannot but regard them as being of the same nature.

The following are the four cases referred to :—

(1.) G. G., a girl aged 10, was taken ill suddenly some time in October 1890 (precise date cannot be fixed) with vomiting, sorethroat, flushed face, dyspnœa, pain in the chest, and cough, and remained ill a fortnight. She had no obvious rash, but she "peeled all over" and lost a good deal of flesh. Her illness was diagnosed as "suppressed scarlet fever." There were three more children in the house aged 13, 9, and 7, none of whom had had scarlet fever, and none of whom took it on this occasion. The mother says her own throat was bad at the time her girl was ill. None of the other children took "pneumonia."

(2.) A. H., a girl aged 6, was suddenly seized some time in the beginning of October 1890 with vomiting, drowsiness, dyspnœa, cough, fever, and sorethroat. She had a rash "like scarlet fever," and afterwards her skin peeled off. Her mother says this girl had true scarlet fever only two years ago, and peeled then. Three days after this girl's attack, her brother, aged 9, was taken suddenly ill, precisely like his sister, but without any rash. He did not peel. He, however, became jaundiced towards the end of his illness, and had a critical epistaxis, as well as a very profuse sweating about the 10th day. Both children had much prostration and emaciation, and the girl had several "relapses." Her convalescence lasted 14 weeks, her mother says. The father of these two children had a bad throat in February, and an attack of "pleurisy" on March 1st, lasting about a fortnight.

(3.) B. G., a girl aged 3, was suddenly taken ill on January 18th, 1891, with what was called "scarlatina." She had a red rash and afterwards peeled. She had sorethroat and fever, with herpes of the lips. There were six other members of the family, aged 16, 14, 12, 10, 6, and 5 years respectively. None of them, so far as the mother knows, have ever had scarlatina, and none of them took it on this occasion, though there are only two bedrooms for the whole family and the affected child was in no way separated from the rest. The mother says all the children had "bad throats" in December, *i.e.*, about three weeks before this little girl was taken ill. I am inclined to regard these sorethroat cases, as well as the youngest child's case, as forming part of the prevalent malady.

(4.) L. P., a girl aged 5, was taken ill suddenly on February 1st with vomiting. cough, sorethroat, dyspnœa, and flushing of face, on the *third day* a scarlatina rash appeared; her neck, too, was swollen. She had a nasal discharge. There was some delirium during the early part of her illness, and she bled at the nose, lost flesh, and sweated profusely towards the end of the attack, which lasted two weeks. She afterwards peeled.

On February 3rd her sister, aged 7, began to be ill. She had vomiting, sorethroat, cough, pain in the chest, fever, flushed face, shortness of breath, and discharge from the nostrils. There was no rash, and her skin did not peel. She bled at the nose, and sweated profusely at the end of the acute stage of her illness. On February 21st a third child, aged 3, was taken ill with vomiting, sorethroat, and "bronchitis," but in this case also there was no rash and no peeling. The mother and two older children, aged respectively 14 and 11 years, had sorethroats, just after "the illness" began in the house. I do not regard the first of these cases in this family as having been scarlatina, but rather a modified case of the prevalent "pneumonia" of which the subsequent cases in the family reverted to the more common type.

Heyford in the Northampton Rural Sanitary District.

Heyford is situated about 22 miles south-west, as the crow flies, from Raunds, and is distant 6½ miles nearly due west from the town of Northampton. The populous parts of the parish consist of two aggregations of dwellings, Upper and Lower Heyford, separated from each other by about a mile of open fields. At the Census of 1881 the population numbered 925, viz., 810 in Lower and 115 in Upper Heyford. Lower Heyford is a pleasantly situated village, much of it being built round a wide open space or "green" on the gently rising ground on the south bank of the river Nene, which is less than half a mile distant. Upper Heyford lies on the northern bank of the river, and about the same distance from it. The subsoil is gravel and alluvium. Heyford cottages have ample space about them. The inhabitants are mostly employed in agriculture; a few find work at some ironworks a short distance away; and only a small number are engaged in the shoe-making industry. Both Upper and Lower Heyford have a cleanly appearance, and of late years sanitary improvements have been carried out. Pail-closets have been largely substituted for the old-fashioned privies. A public water supply has also been furnished in pipes to the lower village. A small brook skirts Lower Heyford, and into it slop water is discharged.

For much able assistance as to the facts of the Heyford outbreak I am indebted to Mr. A. Fuller, of Bugbrooke, who attended, medically, most of the cases. Heyford, he tells me, suffered from influenza in the early part of 1890, but children then were singularly free from attacks.

At the date of my visit, April 17th, I found the epidemic had subsided. I was therefore unable to see any cases in the acute stage, and I was again too late to obtain any pathological evidence on the subject of the inquiry.

From personal interrogation of members of invaded families, and from information supplied to me by Mr. Fuller, I gathered that the epidemic at Heyford had in its clinical features presented a great similarity to that at Raunds, but that at Heyford there had occurred greater abundance of, or at any rate more marked, meningeal symptoms than had been observed at Raunds.

The earliest recognised attacks at Heyford began to show themselves during the last week in February, and cases continued to occur up to the last week in March, a period of about four weeks. During that time 34 families were known to have been invaded in the parish, yielding 72 cases,* of whom two died. There were here, as at Raunds, a number of milder cases, some of which doubtless escaped recognition, as not everyone who was ill at this time sought medical advice. And here also, associated with "pneumonia," there occurred in the same families, among adults and older children, a prevalence of tonsilitis and sorethroat. About a third of the total cases had diarrhœa. Many cases had severe "head symptoms"† along with the chest ailment, and during recovery had purulent discharge from one or both ears. In one adult, who only had tonsilitis, there followed an ear-discharge. In several of the worst cases marked retraction of the head was observed. The two fatal cases died comatose. One of them, Mr. Fuller says, had some purpuric spots on the upper part of the chest, and over the sacral and lumbar regions.

The first fatal case at Heyford was an only child, a girl, aged 5 years. She had been to school on February 24th, and began to be ill that night with vomiting and sorethroat, headache, drowsiness, abdominal pain, and diarrhœa, followed by fever, herpes of the lips, shortness of breath, cough; finally retraction of the head and fatal coma. She died on March 1st, and her death was certified as "acute pleuro-pneumonia."

The other fatal case was a child aged 22 months, who was taken ill on February 25th. She had vomiting and drowsiness, followed by diarrhœa, cough, fever, and embarrassed respiration. Later on there was squinting, coma, and convulsions. She died on March 2nd, and the cause of death was certified as "acute broncho-pneumonia." When the child was taken ill the grandmother with whom she lived also suffered from diarrhœa, headache, and feverishness.‡

The symptoms described to me by parents of children attacked were vomiting, drowsiness, cough, sorethroat, flushing of the face (Mr. Fuller says in some cases the child looked "cyanosed"), fever and prostration, with shortness of breath. In many cases the physical signs of pneumonia were present, but in some it appears that none could be made out, although hurried breathing was a marked feature of the case. The chest affection in some cases, Mr. Fuller states, was bronchitis, in others broncho-pneumonia, and in others there was undoubtedly acute lobar-pneumonia. It may be stated generally that the chest affection varied from capillary bronchitis to pleuro-pneumonia. Mr. Fuller noted ex-

* I am informed by Mr. Fuller that he has seen three fresh cases, and these occurred at the end of April.

† Severe headache, drowsiness, delirium, screaming, convulsions.

‡ It deserves mention that the mother of this child died two years ago, aged 29, at Heyford, from suspected cerebro-spinal meningitis. The main features of her illness were violent headache, fever, squinting, paralysis of the right side, retraction of the head, and coma.

treme hyperæsthesia over the abdomen in some instances. Some children complained of "stiff neck."

One case I saw had not quite recovered on April 17th. This child, a girl, aged 18 months, began to be ill on March 1st with the usual symptoms, viz., vomiting, drowsiness, cough, "panting for breath," fever, flushing of the face, and diarrhœa; there was also running from the eyes. She had convulsions later on, and became blind; her head was retracted at right angles to the spine. There was "sudamina" on the chest and abdomen. She had paralysis of the left side (arm and leg). She had a squint. After three weeks' dangerous illness, in which she became greatly emaciated and had incontinence of urine, she began to recover. During convalescence her skin peeled. Her sight returned, as also did the use of her arm and leg. The squint also disappeared. The case had been regarded at first as one of "broncho-pneumonia."

In other cases the lung affection was accompanied with nervous symptoms. For example, one boy aged 6½ years, a more recent case, complained on getting up for the first time after 10 days' illness, that he could not feel his legs, and he was very shaky in his attempts to walk. The boy was said to have had "catarrhal pneumonia"; he slept through most of his illness, and was waked up with difficulty to be fed. He had muscular tremors in the acute stage of the attack. His illness began with vomiting and diarrhœa.

There can be no doubt, therefore, that there was at Heyford an epidemic of "pneumonia" in which patients suffering therefrom presented also cerebro-spinal symptoms. In this connexion it may be stated that at Heyford, in April of 1890, three cases of "cerebro-spinal meningitis" occurred in one house. One case, aged 4½ years, which was diagnosed at first as "capillary bronchitis," died after some days' illness; another, aged 6½, recovered in three weeks, but died in November following, never having regained her usual health; while the third, aged 3 years, made a good recovery, but had an ear-discharge. The symptoms in these three cases did not differ greatly from those exhibited in the epidemic under consideration. They were described by the parents as vomiting, dizziness, diarrhœa, fever, flushing of face, panting for breath, cough, and retraction of the head.

The following table shows the course of the Heyford outbreak:—

								Houses invaded.
				1891.				
Households invaded during week ending				February	7th	-	-	—
,,	,,	,,	,,	,,	14th	-	-	—
,,	,,	,,	,,	,,	21st	-	-	—
,,	,,	,,	,,	,,	28th	-	-	4
,,	,,	,,	,,	March	7th	-	-	16
,,	,,	,,	,,	,,	14th	-	-	12
,,	,,	,,	,,	,,	21st	-	-	2
,,	,,	,,	,,	,,	28th	-	-	—
,,	,,	,,	,,	April	4th	-	-	—
,,	,,	,,	,,	,,	11th	-	-	—
Total households invaded up to April 11th*						-	-	34

* During the last week in April Mr. Fuller tells me one new case occurred in a fresh family, and two other cases in households previously invaded.

As at Raunds, the malady chiefly attacked young children under 5 years of age. Multiple cases in families were frequent. In nine

families there was a single case, but in 25 there were two or more cases. According to Mr. Fuller's statement there was no similar epidemic illness in any of the surrounding villages.

As in the case of Raunds, I made inquiry as to school influence on the outbreak, but again with negative results. At Heyford, however, the influence of the epidemic on school attendance was greater than at Raunds, as will be seen from Table B. at the end of this report.

Kettering and Northampton.

Fourteen replies were received by me in response to letters addressed to a number of medical men practising in Northamptonshire. For the most part none of my correspondents had anything but negative evidence to offer for their districts. Nevertheless, in particular instances, some interesting facts were forthcoming.

From Dr. Dryland, of Kettering (about 9 miles N.W. from Raunds), I learned that during the last few months he had had a great prevalence of pneumonia, and many sorethroats among people of all ages. In three cases lately, he says, children recovering from pneumonia have had discharge from both ears. He also adds (May 7th), "I have not only seen "cases suggesting modified manifestation of cerebro-spinal meningitis, "but I have also seen what I take to be that complaint in a distinct "form in three or four instances."

The above statements of Dr. Dryland seem certainly to point to the occurrence of cases of a similar kind to those at Heyford and Raunds, though in smaller numbers.

From Northampton ($6\frac{1}{2}$ miles from Heyford) I have from several sources heard of numerous cases of anomalous illness variously designated. For instance, Dr. Perceval tells me of a case of which he knew, and which died on January 3rd, 1891, from "rheumatism and meningitis." The patient, a girl of 17, began to be ill about December 14th with pains in her joints and hyperæsthesia; temperature throughout about 102° to 103°. She had headache, double optic neuritis, delirium, a tendency to retraction of the head, and general flexion. Later on bedsores formed; she lost power over the sphincters, developed meningeal cry, and died comatose. A similar case, but not fatal (under the same roof as the last), was a boy aged 15, who became ill in September 1890. His symptoms were vomiting, diarrhœa, earache, afterwards meningeal cry, loss of control over sphincters, slight paresis of arms, delirium, and tendency to coma. No retraction of head was noted in this case. Gradual recovery took place after 13 days' illness. He had an eruption of "lichen papulatum" from commencement of the attack. This lad came from Bugbrooke, which is only $1\frac{1}{2}$ miles from Heyford. But there had not been any similar illness at his home.

From Dr. Marriot (of Northampton) I heard that in his practice he, in December last, had attended a child, aged 18 months, whose illness began with broncho-pneumonia, which was followed by cerebro-spinal symptoms. She had paralysis of both legs, but after some weeks' illness she recovered. A sister, aged 3, had some acute symptoms about the same time, but her illness was only what her mother called "a stuffing at the chest." She had no meningitis. A baby was born to this family at Christmas when the two children were recovering; it died on February 26th from "bronchitis." Dr. Marriot also tells me he had in January a fatal case (a boy aged 15) of "lobar pneumonia followed by cerebro-spinal meningitis," in a street not above 300 yards from the house where the children just spoken of resided. Dr. Marriot says, "I have

"had several other cases of basic meningitis in children but not "connected with pneumonia."

I heard also of the following deaths in Northampton from Dr. Cogan, the Medical Officer of Health for the borough :—On March 27th a case, aged 47, was certified from "influenza, meningitis." On March 28th another patient, aged 28, was certified to have died from "spinal menin- "gitis, pneumonia; two days."

Summary.

There can be little doubt but that since December last (1890), or even before this, there has been showing itself a marked prevalence of pneumonia, associated with tonsilitis and now and again with brain symptoms, in certain parts of the county of Northampton. Sometimes the pneumonia has been the leading feature of the illness, sometimes the brain symptoms. In some cases both have appeared together.

The leading character of the Raunds outbreak was on the whole pneumonic,* meningeal symptoms being subordinate and infrequent; whereas in the Heyford epidemic, although pneumonic illness was common, yet there was a marked prominence of symptoms pointing to cerebro-spinal meningitis. This would seem to apply, though in a less degree, to the cases heard of in the Kettering and Northampton districts.

TABLE A.

Showing Average Attendance at the two Public Elementary Schools at Raunds from January 1891 to April 1891.

	National School.		Wesleyan School.		Total Attendance at the Schools.
	Infants.	Boys and Girls.	Infants.	Boys and Girls.	
Number of children on the books	162	170	—	—	—
Average attendance for last year	90	131	—	—	—
Average daily attendance for week ending January 9	62	120	64	97	343
" " " " " 16	84	125	68	99	376
" " " " " 23	81	123	73	99	376
Epidemic Period. " " " " " 30	99	135	71	130	435
" " " " February 6	122	144	76	134	476
" " " " " 13	108	142	76	136	462
" " " " " 20	90	135	58	130	413
" " " " " 27	75	129	52	120	376
" " " " March 6	100	129	72	130	431
" " " " " 13	91	131	63	126	411
" " " " " 20	113	133	79	135	460
" " " " " 27	112	135	86	132	465
" " " " April 3	Easter.		Easter.		Easter.
" " " " " 10	126	140	89	131	485

The most marked fall in attendance is noted among the infants for the last two weeks in February at both schools. The epidemic on the whole does not appear to have influenced much the school attendance.

* It deserves to be mentioned that some time at the end of August or beginning of September 1890, Dr. Mackenzie had, he now tells me, two cases of pneumonia, one after the other, in a gipsy family encamped upon the roadside near Raunds. The illness of these two children, aged 3 and 5 years respectively, was in his opinion identical with the epidemic malady which afterwards occurred at Raunds. This circumstance suggests a mode of importation of the disease, and the nomadic habits of the family would furnish opportunities for infecting more than one place.

TABLE B.

Showing Average Weekly Attendance from January 30th to April 10th at Heyford Village School.

		Boys and Girls.	Infants.
Number of children on the books - - - -		149	84
Average attendance for the last completed year - -		91	76
Average daily attendance for the week ending	January 30 -	118	62
" " " "	February 6 -	114	61
" " " "	" 13 -	121	57
" " " "	" 20 -	119	56
Epidemic Period. " " " "	" 27 -	113	55
" " " "	March 6 -	106	37
" " " "	" 13 -	88	32
" " " "	" 20 -	98	40
" " " "	" 27 -	101	43
" " " "	April 3 -	Easter.	
" " " "	" 10 -	102	49

No. 8.

On an Outbreak of Scarlatina at Bush Hill Park, in the Enfield and Edmonton Urban Sanitary Districts; by Dr. S. Monckton Copeman.

Bush Hill Park, a building estate of some 370 houses, partly in Enfield, partly in Edmonton, is situated, as will be seen from the accompanying map, on either side of the Great Eastern Railway line which runs from Liverpool Street to Enfield; the station at Bush Hill Park being about midway between the Lower Edmonton station on the south and that for Enfield town on the north. From each of these places it is separated by a considerable extent of market gardens, and as the roads connecting it with Enfield and Edmonton are few and for the most part in bad condition, the railway affords the readiest mode of access to the estate.

On the western side of the railway the houses (some 60–70 in number) are all of the better class, the rateable value ranging from 52*l.* to 60*l.*, while those on the eastern side of the line (some 300) are considerably less pretentious, as will be seen from the fact that in this portion of the estate the rateable value of the houses varies from 8*l.* to 20*l.*

Scarlatina which in the first ten months of 1891 had prevailed more or less in several localities of Enfield and Edmonton, hardly affected Bush Hill Park, only four cases having occurred there, all of them in June. But about the middle of November Bush Hill Park suddenly began to suffer greatly in excess (relatively to its population) of other and neighbouring localities. In the eight days, 17th to 24th November, no less than 23 households in Bush Hill Park were invaded by scarlatina, 33 of the inhabitants being meanwhile attacked by the disease. Very soon after the occurrence of the outbreak of this scarlatina the Medical Officer of Health of Edmonton (Dr. Green) ascertained that so far as his district was concerned all the then known cases of the malady in Bush Hill Park had but one condition in common, namely, that their families obtained milk from a particular retail dealer in the Edmonton district; and upon conferring with Dr. Ridge, the Medical Officer of Health for Enfield, he learned that the like was true of all known Bush Hill Park scarlatina cases in Dr. Ridge's district. In illustration of the evidence of this class upon which Dr. Green's further proceedings were based, I supply a table of the facts as to the incidence of this scarlatina on the Enfield and Edmonton sections of Bush Hill Park. The data in question differ from those originally got together by Dr. Green solely in the circumstance that they are supplemented by a few additional facts as to scarlatina attack that were obtained subsequent to my arrival in the district.

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On Milk-Scarlatina at Bush Hill Park; by Dr. Copeman.

TABLE of SCARLATINA CASES in BUSH HILL PARK (ENFIELD and EDMONTON URBAN SANITARY DISTRICTS) during November 1891.

Date in November 1891.	Houses newly invaded getting Milk—		Persons attacked in Household getting Milk—	
	wholly or in part from the particular Dairy.	from sources other than the Diary in question.	wholly or in part from the particular Dairy.	from sources other than the Dairy in question.
1st	—	—	—	—
2nd	—	—	—	—
3rd	—	—	—	—
4th	—	—	—	—
5th	—	—	—	—
6th	—	—	—	—
7th	—	—	—	—
8th	—	—	—	—
9th	—	—	—	—
10th	—	—	—	—
11th	—	—	—	—
12th	—	—	—	—
13th	—	—	—	—
14th	—	—	—	—
15th	—	—	—	—
16th	—	—	—	—
17th	4	—	4	—
18th	3	—	5	—
19th	3	—	6	—
20th	5	—	8	—
21st	3	—	5	—
22nd	3	—	3	—
23rd	1	—	1	—
24th	1	—	1	—
25th	—	—	—	—
26th	—	—	—	—
27th	—	—	—	—
28th	—	—	—	—
29th	—	—	—	—
30th	—	—	—	—
	23	—	33	—

Having observed that houses supplied from this particular milk-service were specially attacked, Dr. Green, accepting the primâ facie case against the milk, directed his inquiries to the discovery, if possible, of any means

LONDON ROAD

LINCOLN ROAD

PARK WEST

BUSH HILL

THE VILLAGE ROAD

THE PRIVATE ROAD

WELLINGTON ROAD

GREAT (ENFIELD BRANCH) EASTERN RAILWAY

Footbridge

CARDIGAN ESTATE

EAST CRESCENT

MAIN AVENUE

FIRST AVENUE

SECOND AVENUE

FOURTH AVENUE

FIFTH AVENUE

SIXTH AVENUE

SEVENTH AVENUE

PERCIVAL ROAD

BERTRON ROAD

BUSH HILL PARK EAST

ENFIELD

EDMONTON

U.D.

S.D.

Enfield Parish
Edmonton Parish

QUEEN ANNE'S PLACE

DAIRY

Bush Hill Park Station

Bridge

• *Denotes Houses having Cases of Scarlet Fever*

Scale

feet 100 50 0 100 200 300 400 500 600 700 800 900 1000 1100 1200 feet

Judd & Co Ltd, Lith. 63, Carter Lane, Doctors' Commons. 3554.5.92

of infection of this milk, whether at Edmonton before or during its distribution there, or at the farm from which it was derived,—making a journey for this latter purpose to Essex where the farm was situated. As the result of his inquiries in both directions he came to the conclusion that the milk must in some way have become infected previous to its reception by the dealer at Bush Hill Park, and he further inclined to the view that infection had probably come about from some human source at the Essex village, where there had been, he found, one or two cases of the disease in houses adjacent to the farm.

At this stage he very properly made a report of the facts to the Sanitary Authority and to the Local Government Board; and the Board, finding three sanitary districts involved in the matter, decided on an inquiry by one of its own officers, and directed me to make it.

Before following up the clues suggested by Dr. Green's investigations I thought it desirable first to eliminate other possible methods of scarlet fever dissemination at Bush Hill Park, and with this object I, on going down to Enfield, first directed my attention to the water supply, the drainage system of the neighbourhood, to school attendance, and to the likelihood of intercommunication of those who had been attacked with infected houses in outlying districts. It speedily became apparent that in none of these various directions could any condition be found common to all or even any considerable proportion of the cases which had occurred at Bush Hill Park. As a matter of fact the Enfield and Edmonton portions of the estate have distinct sewage systems, the earliest sufferers were, many of them, below school age, and none of the persons attacked or other inmates of their houses had, as far as could be determined, come in relation with previous scarlatina. The water of the New River Company is indeed supplied to all the houses of Bush Hill Park as to other houses of Enfield and Edmonton, but no evidence whatever was forthcoming from these other parts of Enfield and Edmonton, tending to implicate water supply as a cause of the fever.

Proceeding next to inquiry respecting milk supplies in Bush Hill Park, I ascertained that at the time (17th to 24th November) of the outburst there of scarlatina, the inhabitants were being served by at least three different milk vendors. The bulk of them, however (more especially west of the railway), obtained milk from a particular dairyman whom I will call Mr. X. His place of business is situated on the estate, and some of his milk was being distributed also in quarters of Enfield other than Bush Hill Park. Further I ascertained, in concert with the medical officers of health of Edmonton and Enfield, that of scarlatina occurring in Bush Hill Park during the eight days 17th to 24th November, every individual case that could be heard of had been among persons obtaining milk from Mr. X.

Upon conferring with Mr. X. in view of the above facts, and for the purpose of securing his assistance in my inquiry, I discovered his attitude to be one of scepticism towards milk-scarlatina. He was not

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prepared to regard his milk as under any circumstances a cause of illness, and with reference to the Bush Hill Park outbreak proceeded to furnish me with statements which in his opinion went to show that his milk could not have been concerned with the outbreak of scarlatina there. At the date of my arrival on the scene Mr. X. was obtaining the bulk of his milk from a source other than that it was being derived from at the time the scarlatina occurred among his customers, this change of milk source having resulted from the intervention of the Edmonton Sanitary Authority. So he was sore on the subject of interference with his milk business, complaining, too, of the pecuniary loss he had thereby sustained, and to a corresponding extent was indisposed to help forward my inquiry except in the negative direction, to which I have already referred. Moreover, he declined under the circumstances to furnish a list of his customers.

The negative aspects of the case as presented by him were mainly two:—

1. That few of his customers had suffered scarlatina; that indeed, so far as his business was concerned, certain households only in Bush Hill Park west of the railway had been invaded, whereas his milk service had included not only many in Bush Hill Park East, but a number of households also in the direction of Enfield town, all of which had escaped illness.

2. That scarlatina in Bush Hill Park had not been limited to his customers, but had attacked also the customers of other milkmen.

As to contention No. 1, this was found on inquiry to be contrary to fact. Not only was it found that certain of Mr. X.'s customers in Bush Hill Park East suffered coincidently with his customers in Bush Hill Park West but other customers of his in the neighbourhood of Enfield Town, had at the very same time suffered from scarlatina disproportionately to other persons there. It is true as regards Bush Hill Park that there had occurred—if a general statement of Mr. X.'s as to the number of his customers in the East and West divisions of this locality is to be relied on—a larger incidence of scarlatina on better class-households served by him than on poorer households also getting his milk. But the circumstance of course (if it were a fact) went for little in exculpating Mr. X.'s milk, since in other milk-scarlatina outbreaks differences in the quantity of milk consumed by different classes of persons has been found to have much concern with their attack or escape from the malady. Nevertheless it was a matter well deserving investigation had Mr. X.'s attitude towards the inquiry permitted.

Similarly, with reference to Mr. X.'s second contention, namely, that householders in Bush Hill Park *not* getting milk from him, had, notwithstanding, suffered from scarlatina in November last, it needs but to remark that after much inquiry, I failed altogether in obtaining facts supporting such statement.

Accordingly, the presumption against Mr. X.'s milk as the cause of the scarlatina having become in no way weakened by consideration

of the negative aspects of the case, the next question was, How did the milk become infective?

With reference to this, it has to be noted that Dr. Green had at an early stage of the outbreak carefully examined the various persons employed at the dairy, but had failed to find in any one of them any sign or symptom of their having recently suffered scarlatinal disease. Similarly he had ascertained that with the sanitary and business arrangements of Mr. X.'s premises no fault could be found. These facts I made it my business to verify, as well as the further fact that though Mr. X.'s household and the household also of one of his milk carriers did in the end become invaded by scarlatina, members of these families did not begin to be ill until a date in November some days subsequent to the commencement of the fever in Bush Hill Park. Nor did I, under the circumstances of slender assistance from Mr. X., spend time in attempt at minute differentiation as regards infectiveness between the milk derived from Mr. X.'s three cows and the bulk of his supply which came from Essex. According to Mr. X. the milk of his own cows by itself furnished the "nursery milk" of his business, was distributed almost wholly to his better-class customers, and with a single exception was not served to any house that did not also receive the ordinary milk of his business that came from Essex. The household receiving "nursery milk" but no other milk from Mr. X. had not, I found, suffered from scarlatina; and further, within the limits of Mr. X.'s own household, an infant of his fed with "nursery milk" had, I found, escaped scarlatina, whereas a daughter aged 3, who habitually consumed Essex milk, was attacked coincidently with his customers.

The evidence thus far having gone to indicate that the scarlatina outbreak under consideration in so far as it had been due to Mr. X.'s milk was referable to that section of it received by him from Essex, it appeared desirable to visit the district in which the farm supplying this milk was situated. Intimation of the proposed visit was therefore sent to the Medical Officer of Health for the district in question and to the farmer, with a request for assistance in my investigation. The facts, as they appeared thus far, were explained to the farmer (whom I will call Mr. Y.), and although he was evidently unconvinced that his milk had in any way been at fault, it is expressly due to him to say that he afforded every facility in his power for the conduct of the inquiry. At this time, as has been said, he was no longer supplying milk to Mr. X. at Bush Hill Park, as, through the action of the sanitary authorities for Edmonton and Enfield respectively, this Essex supply had been stopped as soon as it appeared probable that it had been the source of infection; Mr. X. thenceforward making up the amount required in his business from a farm in Derbyshire.

Upon stoppage of this Essex milk by the Edmonton and Enfield sanitary authorities, one day's supply of milk returned on the hands of the farmer, as also the produce of his cows for the next two days, was thrown away on the farm; after which, and with the sanction of the local

Medical Officer of Health who was unconvinced as to Mr. Y.'s milk having had anything to do with the outbreak at Bush Hill Park, a new contract was entered into by the farmer with the proprietors of a dairy in the East End of London.*

The number of cows owned by Mr. Y. was found to be usually about 25, while the average yield of milk was 40 barn gallons per diem. For a period of two and a half years it had been *all* sent to Mr. X. at Bush Hill Park, with the exception of a small quantity kept back for home consumption. On asking as to the destination of the milk which was held back each day at the farm, it was stated that it was used for the most part in the farmhouse, while a small portion was supplied to a general shopkeeper in the village (Mr. Z.). Of the latter portion, some was used in Mr. Z.'s own house, and occasionally he managed to sell a small amount to other of the villagers. But this was not a frequent occurrence, as several of the villagers when interrogated on the subject stated that they could not afford to buy new milk and so had dispensed with its use altogether. The cows at this Essex farm were attended to by a man and his two sons, who lived together in the village at a cottage where also resided the man's wife and daughter. These persons in like manner with the other inhabitants of the place never bought any milk, and not being allowed to take any direct from the sheds, they went, I was told, without it, unless by chance, as happened on rare occasions, they received a little from the farmhouse.

It will thus be apparent that as a matter of fact only two houses in the village (those of the farmer Mr. Y. and of the shopkeeper Mr. Z.) were regularly supplied by milk from this Essex farm, and on looking over the list of cases of scarlet fever in the village recently notified to the Medical Officer of Health it was found that while cases had occurred in these two houses (one in the farmer's family and two in that of the shopkeeper), the village had, with one exception, remained exempt. Furthermore, it appeared that the three cases first mentioned had all fallen ill on the same day, November 17th, coincidently therefore with the first batch of those affected at Bush Hill Park.

The exception above referred to as not having consumed milk from the farm, was a girl aged 10 years, who was taken ill on November 19th, two days after Mr. Y.'s and Mr. Z.'s children. So far as could be learned she had not been in relation with the other three patients or with other antecedent scarlatina, and her illness was therefore difficult of explanation.

It transpired, however, that this girl attended the village National School, the playground of which is just on the opposite side of the road to Mr. Y.'s cowsheds, outside of which the churns in which the milk was sent up to town were placed while waiting to be filled. And locally it was thought possible that she might have found opportunity of helping herself to some of the milk. But however this may have been, of one fact there could be no question, namely, that scarlatina which occurred simultaneously at Bush Hill Park and in this Essex village attacked in each place earliest and disproportionately to other persons individuals who had been consuming Mr. Y.'s milk. It next became necessary to discover if possible the manner in which the milk had itself become contaminated.

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* Seemingly Mr. X.'s milk had ceased to be infectious antecedent to his relinquishing supply from Essex in favour of supply from Derby. He discontinued using Essex milk November 25th, and the last case of scarlatina among his customers was notified November 24th.

The cows were kept in sheds, ranged round three sides of a square yard, the fourth side being open, while built on to the sheds was a small stable, and buildings in which food for the cattle was stored and chopped. These sheds were at a distance of a hundred yards or more from the farmhouse, none of the inmates of which ever went near them, even the farmer himself having abstained from doing so since August last, as at that time there had been a case of scarlet fever in his house. The cows were attended to, as has been stated, by the cowman and his two sons, the younger of whom went as far as the porch of the farm-house every morning for the key of the cowsheds, which was hung up on a nail there, returning with it again in the evening. He never, it was confidently affirmed, went into the house. The cows were milked twice in the day, small pails being used, and the milk from the whole number of cows was mixed and strained before being passed into the railway churns.

During the whole of this process neither the cowman nor his sons left the buildings, but on alternate days one of these latter afterwards took the churns on to the station,* the milkboy of a neighbouring farmer performing this office every other day. When examined this boy, like the cowman and his family, showed no signs of having recently had scarlet fever. Neither had any of them, as far as they knew, been near anyone who had been suffering from the disease.

The milk-cans were always scalded in London and rinsed out at the farm with clean drinking water.

None but negative evidence having so far been elicited on the subject of infection of the milk from some human source, the question was seen to be arising here, as it has arisen elsewhere, of some diseased condition of the cows themselves as perhaps responsible for infection of the milk. But when this possibility was suggested, a veterinary surgeon, who had been in frequent attendance at the farm for some years past, asserted positively that within the last twelve months nothing of a contagious nature had been present among the cattle. He, however, volunteered the statement that on one or two occasions there had been small abrasions on some of the cow's teats, but said that there had been no characteristic eruption, nor any scaling whatever. And the cowman admitted that he had noticed a "push" or boil on the udders of some of the cows lately, adding that this is frequently seen in cows having their first calf.

The cows were accordingly carefully examined one by one, the cowman being asked to point out any instance of a "boil" which was then to be seen. This he did, and three cows out of the whole number were found to have some swelling on either udder or teats, while in two cases on the surface of the swollen part was found one or more "boils." These presented different stages, one "boil" being found which consisted of a vesicle rather larger than a shilling with a central somewhat depressed brownish scab; others were not so advanced, no "head" being visible in one instance. The cowman, however, stated that the swelling always came before the "boil," and both gradually disappeared together, leaving usually a slight scar. One or two such scars be showed me and explained, without being questioned on the point, that they were quite different from the "chaps" which sometimes come from milking in cold weather. He was evidently quite incredulous, however, as to there being anything really the matter with the cows, particularly since, as he said, none of them had refused their food. It was noticeable, however, that two of the animals, on one of which the large vesicle was found, were

* This was on November 16th, 18th, and 20th.

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coughing a good deal even when not feeding, and that one of these two did not look in particularly good condition.

At this stage of the investigation I applied to the Board to afford me further scientific assistance, and Dr. Klein was instructed to join me in the inquiry. Having made an appointment with him, therefore, we journeyed down to the Essex farm three days later than that on which I had first examined the cows there. On examination of the animals Dr. Klein found that the vesicle with a central scab, which I had at first noticed, had now become one large brownish scab; and as at this time it was the only one to be found which was unbroken, Dr. Klein removed the thick crust with antiseptic precautions, thus exposing a somewhat deeply excavated ulcer, from the surface of which he took several scrapings for purposes of inoculation. His account of his further investigation of this case is appended to this report.

On going into the previous history of his cows with the farmer, it appeared that from the end of December 1890 until the middle of June last, all the cows that were in calf had aborted with the exception of two. He therefore gradually got rid of his whole stock save these two, which, on August 14th, he sent to a farm at a distance, owned by his brother, while he instituted a thorough cleansing and disinfection of his sheds, which occupied about a week. All this time, however, milk was being sent by him to Bush Hill Park, mostly from his brother's farm. After having cleansed and disinfected his sheds he had gradually restocked them with cows bought at different dates, those most recently obtained having been bought on September 10th and 24th, October 12th and 27th, and November 14th respectively. These had all been put into the sheds as soon as they were bought, together with the two cows of the previous stock which had not aborted, no system of preliminary quarantine being observed. One cow bought on November 14th yielded but very little milk, but did not show any obvious sign of udder affection; another bought on October 27th had again been sold on November 14th, while the others still remained on the farm; one of two bought on September 24 being that which showed the large scab, previously mentioned, on one of her teats. The cowman had paid no attention to what he considered an altogether unimportant matter and was quite unable to give any trustworthy information as to the order in which the cows had been affected. Consequently it was impossible to single out any one animal as that by which the malady had in the first instance been introduced.

Note by Dr. Klein, F.R.S.

The cow referred to by Dr. Copeman as examined by us on the occasion (14th December 1891) of our visit to the Essex farm, presented at that date, on the right front teat, an induration of the skin and subcutaneous tissue about the size of a large filbert. This induration was fairly well circumscribed, and was surmounted by a brownish rounded scab about $\frac{3}{4}$ to 1 inch in diameter. The centre of this scab was somewhat convex; the peripheral portion flat, showing here and there indications of vesiculation.

On proceeding to remove the scab with forceps, several drops of purulent matter oozed from beneath it, and the scab when removed left a highly injected bleeding sore. Scrapings from the deeper part of this sore as well as portions of the scab itself, were taken by me for experiment on animals, and for inoculation also of different culture media.

Cutaneous inoculation of Calves.

On 15th December, the day after the collection of the above materials, calf No. 1 was inoculated, in 50 superficial incisions of the skin of the groin and belly, with a mixture in sterile salt solution of scrapings of the cow's sore and portions of the crust that had covered it.

On the *third* day, 17th December, all the above insertions in calf No. 1 were somewhat raised, and the skin around them slightly injected.

On the *fifth* day, 19th December, all insertions except two had almost dried up. These two, though somewhat swollen, were no longer surrounded by injected skin; but on each was a narrow linear brown scab. Scrapings taken for further experiment from these two insertions on calf No. 1 were :—

On the same day, 19th December, employed for similar cutaneous inoculation (in 20 places) of the groin and belly of calf No. 2. But without obvious effect; for on the *fourth* day, 22nd December, none of the insertions on calf No. 2, appeared either red or swollen, and on the *sixth* day, 24th December, every one of them had almost completely died away.

How far the quasi-negative results obtained in calves Nos. 1 and 2 were due to inherent feeble activity of the material taken from the Essex cow, or were due to drying (and possible attenuation therefore) of this material that had occurred in the 24 hours' interval (14th to 15th December) before calves could be secured for experimental purposes, I am unable to say.

Inoculation of Culture Media.

Minute portions of the purulent matter which had oozed from beneath the scab on the teat of the Essex cow, and portions also of the scrapings from the sore revealed after removal of this scab, were used for inoculation of gelatine plates and of the surface of nutrient gelatine set slantingly in test tubes, and with result as follows :—

Three kinds of microbes were thus isolated :—

(*a.*) Staphylococcus aureus; a limited number of colonies.

(*b.*) A motile liquefying bacillus (probably bacillus subtilis); a single colony only.

(*c.*) A non-liquefying microbe which was the predominant organism. This as shown by its morphological characters,—as well as by its mode of growth in gelatine plates, on the surface of gelatine in tubes and in streak and stab culture in the same material, on Agar, and in broth,—was clearly a species of streptococcus. In *streak* culture especially, this microbe resembled in a marked manner the streptococcus isolated by me from sores on Hendon cows and described in the Reports of the Medical Officer for 1885 and 1886. Accordingly this Essex streptococcus was further tested, as had been the Hendon streptococcus, on mice and as to its behaviour in milk-culture.

Inoculation of Mice.

A particle of a recent culture on Agar of the streptococcus in question having been mixed with sterile salt solution, was injected under the skin of the back in each of four mice. But without result : all four mice remained unaffected. Other four mice were therefore similarly inoculated, but this time with material from a recent broth culture of the

microbe; and in 24 hours all four of these animals were observed to be quiet and off their food. In another 24 hours, however, they were lively and feeding again, and did not subsequently ail in any way. The result therefore of experiment on mice was on the whole negative; and the identity of the Essex with the Hendon streptococcus remained an open question.

Culture of the Essex Streptococcus in Milk.

Several test tubes of sterilised milk were inoculated with material of a first subculture of streptococcus on gelatine and were incubated at 37° C. As a result the milk in all the test tubes of experiment remained fluid, as well as unaltered in other respects after a week's incubation at the above temperature, though the growth of streptococcus therein was abundant. As regards this test, therefore, as also with the other tests referred to, the Essex streptococcus failed to correspond with that obtained from the sores of the Hendon cows and from the blood of scarlatina patients, which it will be remembered exhibited the function of, under like conditions, coagulating the milk experimented on.

April 1892.

No. 9.

Report on an Inquiry concerning the Nuisances arising during the transport of Manure from Towns to Agricultural Districts, and the means available for their prevention or mitigation; by Dr. Parsons.

On Manure Nuisances; by Dr. Parsons.

This inquiry was ordered by the Board in view of the complaints —often strong and reiterated—frequently received by them of the grave nuisances, and sometimes of the alleged injury to health therefrom, arising during the carriage of town manure for use in agriculture.

Occasion of inquiry.

These complaints have had reference chiefly to manure from London; though that from other large towns, as Liverpool, Newcastle, Nottingham, Portsmouth, and Plymouth, has also been complained of in the districts to which it goes. They have come especially from places on the shores of the Thames and Medway below London, and on inlets of the coast of Kent, Essex, and Suffolk, and also from inland places on the railways which traverse the fertile and highly cultivated tracts of land in the neighbourhood of London. These complaints seem to have been on the increase of late years, owing to the increased quantity of manure produced and used through the growth of London on the one hand, and through the substitution of the cultivation of fruit and vegetables* for corngrowing on the other; owing also to the longer distances which the manure has to be conveyed; to changes in the character of the population in the districts to which it goes; and to the increased attention now paid to matters affecting health.

Complaints of nuisance from manure traffic.

Especially in agricultural districts around London.

The complaints have come loudest and oftenest from places of a suburban character situated in rural sanitary districts, and from small towns dependent upon the surrounding agricultural districts. In such places there is often a wide divergence of views and interests between the section of the inhabitants using them as a suburban residence who wish for the amenities of town life, and the agricultural element which often predominates on local authorities, and objects to changes, especially such as involve increased rates and inconvenient restrictions. Hence we are apt to find, on the one side, a tendency to the use of exaggerated language in speaking of manure nuisances; on the other side, a neglect to observe, and a reluctance to enforce, such measures as people may reasonably be expected to take to prevent a traffic which is a source of profit to themselves becoming an annoyance to their neighbours.

In places of a mixed agricultural and suburban character.

It is obvious that the manure traffic as such cannot be stopped, or seriously impeded, as it is a lawful trade, and is necessary in the interests both of the urban and the rural districts. The land must have the manure; the towns must get rid of it; and the interests and statutory powers of railway companies and other carriers have also to be taken into account. The matter is not therefore one in which heroic measures of prohibition can be recommended: the traffic must go on, but the aim must be to reduce its dangers and inconveniences to a minimum by securing attention to such measures of detail as shortening the time in which the manure is on the road, selecting suitable places for unloading, and preventing slovenly and offensive modes of cartage and deposit. How far existing

Manure traffic cannot be stopped.

But care should be taken to avoid unnecessary offensiveness.

* An acre of market garden may receive 40–50 tons of manure annually, equal to a layer of about $\frac{1}{3}$ inch average depth over the whole surface.

legal powers are adequate to secure these objects, and in what directions, if any, an extension of the law is from a sanitary point of view to be desired, will be considered in this report.

Notes of Inspections.

Extent of inquiry.

In order to gain information on these points I have visited many of the places around London from which complaints of nuisance from manure traffic have been received, and have been in correspondence with local health officers as to others. I have conferred with medical officers of health and other sanitary officials in the metropolis, and have received valuable information from them. I have visited under their guidance various places from which manure and refuse matters are sent, such as dust-yards, markets, slaughter-houses, and cattle ships. I have also conferred with officials in other Government departments on certain points arising in the course of the inquiry out of matters within their province.

My instructions were to confine my inspections in the first instance to places around London, and to apply for further instructions if I found it advisable to extend my inquiry to other places. This I have not thought it necessary to do, but some statements as to manure from other towns* will be found in the report. These are based partly on my own previous experience as medical inspector and medical officer of health, partly upon the reports of local medical officers of health.

Local investigations.

Places whither manure is conveyed by rail.

The following are notes of my visits to places, whither London manure is carried by rail.

Swanley Junction.

Swanley Junction, Kent.—This is a junction on the London, Chatham, and Dover Railway, about 17 miles from London, at the point where the branch line to Sevenoaks and Maidstone joins the main line. It is in the district of the Dartford Rural Sanitary Authority. A considerable number of houses have been erected in the immediate neighbourhood of the railway station, and much building is still going on there. The goods station yard has therefore come to be situated in the middle of a populous locality; the nearest house is within 30 feet of a siding on which manure trucks were standing at the time of each of my visits. The yard roadway is in bad repair, and in a filthy state, being covered with manure droppings, and saturated with foul matters.†

The manure traffic at Swanley Junction is not of recent date, but the bulk has very much increased of late years. The station-master informed me that the quantity of manure consigned to Swanley Junction (including May's siding) was about 40,000 tons a year (other informants placed the amount as high as 60,000 tons); he never received less than 20 trucks a day; the greatest tonnage being received in winter, between November and May. Trucks loaded with manure for other places may also have to stand for a time at Swanley Junction before being sent on to their destination. The bulk of the manure is unloaded

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* Speaking generally the manure sent out of London differs from that from the large inland manufacturing towns of the Midlands and North of England in the following respects:—

1. It includes the specially offensive manure from Atlantic cattle ships.
2. The absence of human excrement.
3. The less proportion of coal ashes, owing to the higher price of fuel, and the demand for "breeze" by brickmakers.

The manure of such towns as Liverpool and Plymouth seems to resemble that of London in composition.

† During the fruit season a large traffic in fresh fruit takes place from this station. A jam factory adjoins the goods station.

in the goods yard at Swanley Junction, and carted away thence. Some also is thrown on to the sides of the embankment of the Sevenoaks branch, for the use of the farmers whose land adjoins the line. At my visit I counted 50 manure trucks standing, or being unloaded, at Swanley Junction, besides a heap of stable manure, containing perhaps 100 tons, lying on the embankment within about 100 yards of houses, waiting for the farmer to take it away. May's siding, before mentioned, is on the Sevenoaks branch, about a mile from Swanley Junction, and in an open situation where the manure traffic would occasion much less nuisance than at Swanley Junction, being about 350 yards from the nearest house. It is, however, comparatively little used, as the company charge for manure sent there an extra 3*d.* per ton above the charge (2*s.* 1*d.* per ton), paid not only at Swanley Junction, but at other stations lower down the line as far as Sevenoaks.

The land about Swanley Junction is chiefly cultivated for vegetables and fruit. The manure brought thither consists chiefly of stable manure mixed with street sweepings and other refuse. Much of it comes from the manure depôt of the Newington Vestry. (*See* page 109.) Complaints have been made that it contains the putrid bodies of animals; but the station-master says that it seldom now contains offal or fish.

Numerous complaints have been received by the Board from residents at Swanley Junction concerning the nuisance occasioned by the manure traffic. It was referred to by Dr. Ashurst, then Medical Officer of Health for the Farningham division of the Dartford Rural District, in his annual reports for 1884 and subsequent years, as well as by the present Medical Officer of Health. Public meetings have been held and petitions signed to protest against the nuisance. On April 17th, 1886, a numerously signed petition of the inhabitants of Swanley Junction was sent to the Board, asking them to use their influence with the London, Chatham, and Dover Railway Company to induce them, with a view to abating the manure nuisance, to construct sidings at three points indicated by the petitioners, and stated by them to be convenient to the farmers and to be upwards of a quarter of a mile from dwellings, viz., at Spooner's Lane, at Swanley, and at Westead Lane; at the latter point, a siding ("May's siding," previously referred to) already existing, but requiring enlargement. In accordance with this request the Board communicated with the Railway Company. Their reply dated March 22nd, 1887, (which was only obtained with considerable difficulty, and after two interviews between one of the Board's staff and the secretary,) stated that as the company did not possess available land at any of the places indicated, the purchase of the necessary land, and the construction of the sidings would involve a large capital outlay, and the directors were unable to communicate their final views on the question. Appreciating, however, the importance of minimizing the inconvenience to the resident population of Swanley Junction, they had given stringent instructions at each of their sending stations that the utmost care was to be exercised in order that any highly offensive substances should be excluded from their premises. They had also urged the habitual receivers of the manure to take all measures within their power for the removal of the manure immediately upon its arrival at Swanley Junction. They pointed out, however, that, as common carriers, it was not within their power to refuse to accept at a public station, for conveyance to another public station, manure which was at the time free from noxious smell.

For some time after this,—whether in consequence of a diminution of the nuisance or because it was considered that all had been done which could be,—no further complaints were received respecting manure nuisances at Swanley Junction; but in July 1889, the Board received a com-

plaint from a resident near the Westead Lane (May's) siding, one of those proposed as alternatives to Swanley Junction, of the nuisance occasioned by the large accumulations of manure which were allowed to remain there for days together, as well as of the droppings of offensive matter upon the roads in carting. It was contended, however, by the Rural Sanitary Authority, that though there might always be a heap of manure there, owing to fresh manure being brought as fast as previous portions were removed, yet that each individual portion was removed within a reasonable time of its being brought. I learn that the heap of manure complained of was not actually on the Railway Company's premises, but in an adjoining field close to a lane.

More recently, however, the Board have again received complaints respecting the manure nuisance at Swanley Junction. In October 1891 a medical man wrote calling attention to the great amount of illness which, as he believed, was caused there by manure being placed so near dwelling-houses. The manure complained of, he stated, was not ordinary stable manure, but consisted largely of putrefying animal matter, dead cats and dogs, fish, &c. To this cause he attributed a large amount of diarrhœa, sore throats, and scarlet fever.

As regards the actual state of things at my visit on December 4th, 1891, there was, as I have said, a very large quantity of manure at the goods depôt, both in truck and lying on the embankment, and in spite of its being winter, a very strong offensive smell; although the inhabitants assured me that this was nothing to what it was at times. A similar state of things was again found by me at a visit on September 16th, 1892.

Statements of residents.

I made personal inquiries at each house in the street nearest the goods depôt as to nuisance or injury to health attributed to the manure. This street, which is 115 yards long, contains 24 houses; No. 24, the nearest to the manure wharf, being less than 30 feet distant therefrom, and No. 1, the length of the street further off, or 125 yards distant. At every house complaints were made of the offensive smell of the manure, and at some there were complaints of its affecting health, these being mostly at the end nearest to the sidings. (At the same time there were other causes of danger to health; the street being unrepaired and in a foul state; it was not sewered; and there were defective drains and cesspools near the houses. Sewage nuisances abounded, owing to the circumstance that tap-water had been laid on, while no sewers had been provided to carry off the increased amount of waste liquid.)

The following are examples of the statements made to me by residents:—

A.—The smell often makes her sick when she goes out; can never open her bedroom windows for it. Has never been well since she came here, four months ago. Suffers from congestion of liver, diarrhœa, and vomiting. Her little girl suffers similarly, and her boy occasionally. They were quite well before they came to Swanley Junction.

B.—Complains of the smells, "dreadful smells, not like common dung." She has to shut her doors and windows. Has lived in the street five years. Has not had good health since she came. Is thin and ailing and has frequent diarrhœa, and a child has had congestion of the lungs. Her husband works among the manure, and it often upsets him. It did so when they lived in a neighbouring hamlet before they came here, but the rest of the family had then good health. The smells were not then so close to the house.

C.—"Nuisance from manure terrible at times; such a stench as you "never smelled before; it seems to get right inside you." A lady who came to his shop was made sick by it one day. Has had no illness during the two years he has lived here.

D.—"Smell sometimes something dreadful, makes you feel queer," but has had no serious illness.

E.—"Awful bad smells; worst in hot weather; make them feel sick." No illness.

F.—"Very bad smell; it made her ill once or twice when she first came here after living at the seaside. Gave her diarrhœa, sickness and pain, but she has got used to it now."

At several houses it was stated that the smell was worst in the early morning, and at two that it was worst on Monday mornings. Swarms of flies in summer were also complained of.

I heard of cases of enteric fever which had occurred at Swanley Junction and were attributed to the manure nuisance; but in view of the other sanitary defects existing there, it is difficult to ascribe them to this cause with any degree of confidence.

Dr. Tucker, of Swanley Junction, tells me of a disease locally called "dumb ague" which is endemic in the neighbourhood, and which he believes to be connected with the manure effluvia. It is marked by cerebro-spinal symptoms with enlargement of spleen. It begins with shiverings, which are repeated daily. There are loss of appetite, flatulency, diarrhœa, prostration, pain over the heart and liver, as caused by a tight girdle, and a tender spot on the spine. The tongue is red and dry, and the patient is thirsty in the morning. There is numbness of the tips of the fingers, and a feeling of tightness over the brain; and loss of memory occurs. The temperature during a paroxysm may be 103° to 105° F. in the morning. These cases are not confined to Swanley Junction, though more frequent there than elsewhere; they are also met with on the hills. He is never without one under his care. People are not affected on first coming to the district, but only after two or three years' residence. "Dumb ague."

He quoted the case of a woman living at a farm 1½ miles from Swanley Junction on high ground with a subsoil of gravel over chalk, but where London manure was used, there being always a heap of some 20 to 40 tons within 20 yards of the house. The patient had resided there for 15 months when she was taken with symptoms of cerebro-spinal irritation and intermittent fever. On being sent away she quickly recovered and came back quite well; but after a lapse of five months the symptoms recurred. This happened several times, and after three years' residence she left the place, and has since remained quite well.

Mr. Tucker told me also of people in Swanley Junction who suffered from similar symptoms when much offensive manure was being unloaded, but recovered when the unloading ceased, or in windy weather; the smells being always worst in still weather.

One would have expected, however, that if cases of this kind were really due to manure effluvia, they would have been observed elsewhere in connexion with manure nuisances, which, so far as I know, is not the case.*

* In a report on an outbreak of cerebro-spinal meningitis in 1891 at Hendon, Herts, Mr. Gruggen, Medical Officer of Health, states that the first patient was a hay carter, and was in the habit of going to London with hay, and returning with manure upon which he slept during the return journey. The next case, occurring six days later, was that of a man who at times accompanied him.

Feltham.

Feltham, Middlesex.—This place was visited by me on December 9th, 1891, in consequence of complaints made by a resident as to the nuisance arising from manure traffic at the railway station.

Feltham is about 10 miles west of London on the Windsor and Reading line of the London and South-Western Railway, and in a level fertile market gardening country. It is in the district of the Staines Rural Sanitary Authority, a body whose administration has recently been unfavourably reported on to the Board by Dr. Blaxall. Feltham is a place of a suburban character and increasing in size, but no urban powers or byelaws are in force there or anywhere in the district. I was informed by a member of the Authority that a proposal to apply for urban powers had been brought forward at a recent meeting, but rejected "on account of the enormous expense," and because it was thought that they were unnecessary.

Mr. Ashwell, of Bridge House, Feltham, states that the manure traffic was formerly small, but has largely increased of recent years. The manure trucks were formerly unloaded in the station yard, close to the passenger platforms; but owing to complaints from passengers, the company first limited the unloading of manure to certain hours, viz., before 8.30 a.m. and after 7.30 p.m., and afterwards, withdrawing this restriction, constructed a new siding for manure, which, while removing the nuisance further from the station, has brought it nearer to Mr. Ashwell's house. This house is close to the railway, and the new siding is on the other side of the main rails, about 50 or 60 yards distant from the house. The manure is said to contain soft core, dead bodies of animals, rotting meat and fish. Consignments of 2,000 tons are not unfrequent, three to five or more truck-loads coming at a time. Individual trucks do not remain long on the siding, but there is a constant succession. The manure comes at all seasons of the year, and is generally put at once upon the land. The nuisance from it is worst when the wind is from the N. or E., *i.e.*, in the direction towards Mr. Ashwell's house. It is worse in damp muggy weather than in hot dry weather. Mr. Ashwell suffers from frequent sore throat, which he attributes to the smells from the manure. Dr. Morris, his medical attendant, also attributes the sore throats (follicular tonsillitis) from which Mr. Ashwell and his family have suffered to the manure effluvia. Dr. Morris stated that two years ago there was quite an epidemic of follicular tonsillitis in the lane leading from the railway station at a time when some very offensive manure was being carted. He says that the smell is sometimes horrible, making him ready to vomit his breakfast; it is not like stable manure, but like decaying animal matter. He stated that he occasionally met with cases of sore throat and diarrhœa among farmers and their men working among manure. Two farmers, however, with whom I conversed, including one of those referred to by Dr. Morris, did not believe that injury to health ever arose to themselves or their men from working among manure.

Dr. Willoughby, Medical Officer of Health, says that many people complain to him of the nuisance from the manure at the railway siding; but he has not heard so many of the carting of manure through the street. Similar complaints are also made of the manure traffic at Sunbury, Ashford, and other stations in the Staines Rural District.

At the time of my visit there was little manure at the Feltham siding, and that not specially offensive.

Sunbury.

At Sunbury Station the sidings are close to the platforms. I was informed that in view of the complaints of passengers no manure was carried thither during the summer months.

Paddock Wood and Marden, Kent.—The Board having from time to time received complaints of the nuisance arising from the unloading of fish manure at the Paddock Wood and Marden Stations of the South-Eastern Railway, I visited these places on May 23rd, 1892. They are situated in the heart of the Kentish hop district, and large quantities of manure are received there, especially fish manure, which is highly esteemed for promoting the growth of the hop plant. At the time of my visit, however, the bringing of fish manure had just been discontinued for the summer season, and all that I saw at Paddock Wood was some which had been spread on a hop field the week before, and which being dry, was not then so offensive. The manure consists of the refuse parts of fish, as heads and tails, bones, and guts, not of whole fish which have become spoiled. It is, however, on its arrival very offensive.

Paddock Wood.

At Paddock Wood I was met by the rector and several other inhabitants, who complained most strongly of the nuisance; the smell is said to reach to distances of several hundred yards, and to hang about the roads long after a cart laden with the manure has passed. One gentleman complained of being affected in health by the smell, viz., with diarrhœa and loss of appetite. The sidings at which the manure is unloaded adjoin the passenger station, which is in the middle of the village, and there are about 20 houses within 100 yards of them.

At Marden the sidings are even more objectionably situated than at Paddock Wood, being alongside the approach to the passenger station, so that passsengers have to cross close to the trucks in order to get to the station. They are also within a few yards of a dwelling-house and of the churchyard. About six or eight trucks of manure are received daily. At the time of my visit several trucks of stable manure were being unloaded, and one of offensive tanyard refuse, consisting of lime, hair, and fleshings; and the roadway to the station was littered with droppings. No fish manure had been received for several days, but the smell of decaying fish was still perceptible.

Marden.

Mr. Butterfield, Medical Officer of Health for the Tonbridge and Maidstone Rural Sanitary Districts, in which Paddock Wood and Marden are respectively situated, who accompanied me on my visit, suggests that a siding at Collier Street, midway between Paddock Wood and Marden, would be as convenient to many of the farmers as either of the existing stations, and would be comparatively unobjectionable. He says, however, that the Maidstone Rural Sanitary Authority approached the South-Eastern Railway Company with respect to the nuisance at Marden Station, and were informed that sooner than incur any expense the company would give up carrying the manure, which of course would not suit the farmers.

I understand that the objection on the part of railway companies to provide sidings at intermediate points between stations is based, not merely upon the expenses of constructing the sidings, but also upon the necessity, on a main line, of having a signal-box, and a man in charge. There is, however, already a signal-box near Collier Street.

A branch line is also now being constructed from Paddock Wood to Cranbrook, and possibly a suitable situation might be found for a siding on this line; as I am told that the objections to a siding on a main line do not so much apply to one on a branch.

In 1891, in consequence of complaints from Paddock Wood as to the nuisance from the fish manure, the Board communicated with the directors of the South-Eastern Railway, who replied that they could not find that any nuisance had arisen, and that in view of the necessities of agriculture, and of their obligations under their Acts of Parliament,

they could not refuse to carry manure, but that as far as possible they carried only manure in a fit state.

The following are other places in the neighbourhood of London from which complaints of nuisance from manure traffic at railway stations have been received, about which I have obtained information, though I have not visited them in connexion with this inquiry.

Cookham.

Cookham (*Berks*).—An outbreak of diphtheria in 1889 in the neighbourhood of the station was locally attributed to manure effluvia. Dr. Woodforde writes me that the Great Western Railway Company have now extended their siding for the manure trucks so as to remove them further from the roads in which the greater part of the diphtheria outbreak of 1889 occurred. The manure is also now removed the day after its arrival.

Egham.

Egham (London and South-Western Railway).—Dr. Woodforde informs me that complaints are received of the unloading of manure at this place, though less frequently now than formerly; but from newspapers I learn that they have not entirely ceased.

Welwyn.

Welwyn (*Herts*).—The Rural Sanitary Authority complained in 1889 that truck-loads of foul London manure, containing slaughter-house offal, were allowed to remain, sometimes for days, at the station, causing nuisance to passengers and the families of railway servants. Cases of disease were said often to arise from handling the manure. Mr. Kite, clerk to the Authority, now informs me that upon a representation being made to the Great Northern Railway Company, an extension of siding room was made so that the trucks can be unloaded farther from the platform than was formerly the case, and that by this means, and by unloading them as quickly as possible after arrival, the nuisance has been abated.

Maidstone.

Maidstone (London, Chatham, and Dover Railway).—Mr. Adams, Medical Officer of Health, in his annual report for 1889, speaks strongly of the nuisance which had arisen from the arrival and unloading of London manure and the drawing of it by traction engines through the town. He informs me, however, that it has not recurred since October 1891, owing, as he believes, to the protests which he made having led to the manure being consigned to country stations instead of to Maidstone.

Bexley.

Bexley and Sidcup (South-Eastern Railway).—Complaints have been made from time to time during the past 10 years of nuisances from the manure and offal brought to these stations, which are in the district of the Bexley Local Board. The grounds of complaint are especially that the sidings are too near to the passenger stations, and that through careless carting the manure is allowed to drop on the roads. The Local Board took counsel's opinion, but were advised that so long as their byelaws were complied with, they had no ground of action against the railway company. The clerk informs me that the traffic still causes a very great nuisance at both stations.

Nuisances from manure brought by rail from towns other than London.

The following are instances, among others, in which the bringing by rail of manure from towns other than London has formed subject of complaint:—

At Saltash from Plymouth manure.

Saltash, Cornwall.—Mr. Kerswell, Medical Officer of Health for the St. German's Rural District, complained, in 1883 and 1884, that large quantities of town manure, containing decomposing vegetable matter, putrid blood, rotten meat and fish, were brought by rail from Plymouth to the Saltash Station, and were allowed to accumulate in the station yard, whence the manure was drawn through the town in uncovered carts, to the detriment of the health of the inhabitants. He advised that the nuisance should be stopped by causing the manure to be deposited at a

siding away from the town, or conveyed by water to quays distant from any habitation; that it should be conveyed in covered carts to prevent dropping, and that the carts and quays should be kept disinfected, as the smell remains some time after the heaps are removed.

Later, after the formation of a local board, it was reported that the nuisance from the carting of manure through the streets had been finally stopped, but it was not said how.

In Hexham Rural District, from Newcastle manure.

Hexham Rural District.—In his annual report for 1887 Dr. Maclagan, then Medical Officer of Health, complained strongly of the nuisances occasioned by the importation into the district of Newcastle town manure, to which he attributed outbreaks of diphtheria and enteric fever. In one instance a young man, who had been engaged in unloading this manure, and a railway clerk working in an office close to where it was unloaded, were taken ill on the same day with enteric fever. The manure was said to have contained a large quantity of decomposing vegetable matter and slaughter-house refuse, but probably night-soil would be a main ingredient.

In Southwell Rural District, from Nottingham manure.

Southwell Rural District.—The Medical Officer of Health complained in 1889 of the nuisance arising from Nottingham night-soil, sent to Lowdham, Southwell, and Farnsfield Stations (Midland Railway). He complained of its wet and offensive condition, and of its being sent in such quantities that farmers could not remove it in any reasonable time, and hence it remained at the stations for weeks. Fatal cases of diphtheria had been regarded as connected with the nuisance.

In Cumberworth urban District, from Huddersfield manure.

Cumberworth, Yorkshire.—Dr. Barry, in a recent report on this district, corroborates the complaint of the local Medical Officer of Health as to a manure nuisance at Denby Dale Station. He says, "Denby Dale "Station is situated on a hill-side directly above the most thickly "inhabited part of the district, and waggons containing Huddersfield "manure stand for considerable periods of time in the sidings there "until the farmers fetch it away. I understand that the land to which "it is chiefly taken lies on the opposite side of the valley, and the local "people suggest that the Lancashire and Yorkshire Railway Company "might easily arrange to have sidings there, where the manure would "give rise to no nuisance."

Nuisances from manure conveyed by water.

Places visited in course of this inquiry.

The following places, in which nuisance from water-borne manure has formed subject of complaint, were visited by me during this inquiry:—

Greenhithe.

Greenhithe.—This place is on the Kentish shore of the Thames, in the district of the Dartford Rural Sanitary Authority. The village street is closely parallel to the river, a row of houses intervening; from this a road runs southward, passing the railway station, and crossing the London and Gravesend high road, into an agricultural neighbourhood. Near the London Road are many villa residences.

Numerous complaints have been made to the Board, as far back at least as 1883, of the nuisances arising from the London manure brought by river to Greenhithe and carted thence into the country. These complaints have reference to—

1. The character of the manure brought.
2. The place at which it is discharged.
3. The mode of carting it along the roads.
4. The places of deposit for application to the land.

1. The manure brought by barge is said not to be simply horse and cow dung, but to contain refuse of various kinds, dead animals, bad meat and fish, &c., and to be extremely offensive, especially when the barges have been detained and the manure is in a heated condition.

2. The place of unloading is a public "hard" or landing-place, the use of which is free. It is close to the village street, and is approached by a

passage only 9 feet wide, between two high buildings, viz., a chapel on the one side and an hotel on the other. The barges are floated at high water up to this passage, and the manure is unloaded into carts standing there, under the windows of the above-mentioned buildings. Any air blowing through the passage carries the smell to the houses on the opposite side of the street.

3. The carts are not only open, thus permitting the escape of effluvia, but are said to be so carelessly loaded that the piled-up manure drops off into the roads, where it is ground up by the traffic into fœtid mud; so that the smell of manure prevails even when the carts have gone by.

I saw at the "hard" a notice as follows:—

"Dartford Rural Sanitary Authority.

"Notice.

"All persons carting manure or other like material from this landing-place are particularly requested to prevent the same from spilling, and thus causing a nuisance to the inhabitants.

"(Signed) J. C. Hayward,
"Clerk."

I was informed that after the issue of this notice more care was for a time taken by carters to avoid the spilling about of manure, and to sweep up any that may have been spilled.

4. Complaints are made that the manure is deposited on land too near to dwellings. At a visit paid by me on June 13th, 1892, I saw two heaps of manure lying near the road opposite the row of villas called Cobham Terrace. One of these heaps was a very large one, and consisted of stable manure mixed with house refuse and portions of dead animals. It was within 100 yards of five houses, of which the nearest was only 30 yards distant, and it had been lying there, as I was informed, from the previous Wednesday to the Monday when I saw it. The stench from it was much complained of.

As regards injury to health, Dr. Richmond, Medical Officer of Health, in answer to my inquiries stated that he had recently attended in her confinement the wife of the proprietor of the hotel next the landing-place. This took place in the early morning; a barge-load of manure was being unloaded at the time, and the smell was very offensive. The patient suffered for a week after her confinement from symptoms of blood poisoning, which Dr. Richmond believed to have been due to the effluvia from the manure, but she eventually recovered. He could not quote any other case of serious illness clearly attributable to the manure effluvia, though he says that many people are made to vomit by them. A fatal case of choleraic diarrhœa occurred a few years ago in a house opposite the landing-place, but though the child's illness was attributed by the father to the manure effluvia, Dr. Richmond thinks it quite as likely to have been due to the defective drainage of the house. Diphtheria is endemic in the neighbourhood, but it is difficult to attribute it to the manure nuisances on account of the bad sanitary condition of many of the houses. In a former report, however, (Annual Report for 1885,) he says, referring to the manure nuisance, "the abatement of this nuisance is of "more importance than all the other sanitary work of the district.'

The measures required to prevent the nuisance at Greenhithe seem to be to provide another landing-place; to require the use of covered carts; and to prevent dropping of manure on the roads.

The latter objects might be secured by byelaws under section 44 of the Public Health Act, 1875, or under section 26 of the Public Health Acts Amendment Act, 1890, but the Rural Sanitary Authority have

not put themselves in a position to make such byelaws, having declined to apply for urban powers under either Act. The reason assigned, besides unwillingness to interfere with agricultural interests, is that Greenhithe is a portion only of the parish of Swanscomb, and that the Authority have no evidence that urban powers are needed or desired in the major portion of that parish.

Dr. Collingridge, Medical Officer of Health to the Port of London Sanitary Authority (whose jurisdiction at Greenhithe extends to high-water mark), informs me that he caused application to be made to the Dartford justices for an order against a bargeman to discontinue unloading manure at Greenhithe, as creating a nuisance under the Public Health Act; but the order was refused on the somewhat singular ground that the Inspector of Nuisances, who made the application, was not a person aggrieved.

Dartford.

Dartford, Kent.—The manure coming here is brought in barges up a creek from the Thames to several private wharves on the edge of the town. It has been the source of complaint at various times.

The manager of the London Paper Mills Company told me that the nuisance from unloading manure at the adjoining wharf (Waller's wharf) was sometimes very great, so that women in the factory, which is about 80 yards from the wharf, had sometimes to leave off their work. The late manager, too, could not one day stop at his work owing to the smell making him ill; his office was 30 yards from the wharf.

An entry in the journal of the Medical Officer of Health refers to this as follows: "On August 5th, 1891, at the request of Mr. Reid (manager "of the paper mills), I again visited Mr. Waller's wharf, where manure "was being unloaded. The day was hot, the stench was bad, and "Mr. Reid informed me that it was so strong in his counting-house "that it caused him an attack of diarrhœa. In these circumstances it "is certainly prejudicial to his health."

Complaints have also been received from another factory in the neighbourhood of this smell from the manure at Waller's wharf.

At my visit on December 10th, 1891, I saw at Waller's wharf several heaps of manure, some hot and steaming, and others old and grown over with weeds; one heap might contain perhaps 150 tons. I was informed that some of it was the same as that complained of on August 5th, and had been lying there ever since. The manure consisted chiefly of horse dung, but contained also fish and beef bones, cabbage stalks, rotten turnips, old bottles, old bonnets, sardine tins, a dead dog, &c.

Beadle's wharf, on another branch of the creek, has a number of dwelling-houses close upon it. Here I saw lying several hundreds of tons (16 freights of about 40 tons each) of manure in various stages of decay, some still heating, other portions quite rotten. Some of the cargoes consisted of cattle-ship dung; others contained rags, spent hops, and bullocks' paunches, hair and other refuse from slaughter-houses. The manure is the property of dealers; it comes in the summer, and is stored here, being used on the land principally in the winter.

At Victoria wharf, which is on the opposite side of the same creek as Beadle's wharf, I saw other heaps of manure, some of which were being carted away. Some were of cattle-ship manure, others contained domestic refuse, as old boots and hats, mats, floorcloth, paper, and tins. One heap contained many soiled bandages and other rags, seemingly from a hospital.

The cattle-ship manure is most complained of, as it is strongly heated on arrival. It contains much wasted maize, affording food to rats, which swarm about the wharves. It has a peculiar pungent sour smell, probably due to the fermentation of this maize.

The manure is most offensive when freshly unloaded from the barge, as it is then actively heating: it becomes less offensive after being stacked for a fortnight..

The carting of the manure through the town is also offensive, but the unloading of the barges is most complained of.

The Dartford Local Board have byelaws under section 44, Public Health Act, 1875, following the Local Government Board's Model Series II. These, if enforced, would prevent the storage of manure, unless deodorized (*e.g.*, by covering with earth) within 100 yards of a dwelling or workplace; and would require carts to be covered, and any droppings to be swept up. The Local Board, however, as I am told, do not enforce their byelaws in these respects, for fear of being thought to harass the agricultural interest.

Grays.

Grays, Essex.—Manure is brought to two private wharves on the opposite sides of a small creek leading out of the Thames. The nearest end of these wharves is about 70 yards, and the farthest 140 yards from a continuous row of houses in a street at right angles to them. There are also workshops close to each wharf.

At my visit on June 13th I found lying on one of these wharves three loads, about 180 tons of manure, which came almost up to the windows of one of the workshops. It consisted partly of cattle-ship dung, partly of stable dung mixed with fish refuse. The cattle-ship dung, which was mixed with a little lime, was not very offensive at the time of my visit, which was made on a cool breezy day, but the fish offal, which had been lying for nearly a week, was much complained of by the workmen in the adjacent workshop.

Queenborough.

Queenborough is situated on the Swale, the channel which divides the Isle of Sheppey from the mainland of Kent. Though possessing an ancient municipality, it is in point of size a village consisting of a single street, parallel with the Swale.

The manure brought here contains offal and market sweepings, and comes mostly in the spring of the year, when the farmers are not otherwise busy. It is landed at a public "hard" or wharf, the property of the Corporation, who make a charge of 8*s.* per load, or 1*l.* per barge per year. This wharf is immediately at the back of the main street, about 35 yards from a row of houses. The manure is not thrown upon the wharf, but direct into the carts. Nuisance arises, first and chiefly, during the unloading of the barges, owing to the nearness of the wharf to houses; second, from effluvia given off during the passage of carts along the street; third, from dropping of manure in the streets; fourth, from the pumping out of foul bilge water.

The byelaws (based on the Local Government Board's Model Series II.) in force in the district require carts conveying filth to be covered. A good tarpaulin tied at the corners is found effectual to prevent nuisance during the passage of carts; but some of the tarpaulins used are not so good as they might be, and hence manure rolls off the carts, and the surveyor has often to send men to sweep it up. It is really the duty of the person conveying the manure to do this; but the Surveyor does not like, he says, to be always summoning his neighbours. The principal importer of manure is a member of the Corporation, and has been mayor.

Mr. Swales, Medical Officer of Health, has no evidence that the manure effluvia have occasioned injury to health, though he admits that they are a nuisance. The Surveyor, who lives in one of the houses by the wharf, says that he often can use only the rooms on the farther side of his house, and at times cannot eat his dinner for the smell.

The best remedy would be to provide a wharf farther away from the town (as the Corporation claim the whole water of the creek), but proper covering of the carts would do something to mitigate the nuisance.

Milton.

Milton-next-Sittingbourne.—Much London manure is landed here by barge at a private wharf on Milton Creek, an inlet of the Swale. At my visit, on December 11th, 1891, there was a heap of about 12 tons of manure within 40 yards of a cooperage and a dwelling-house; this heap was then being carted away. Another larger heap, consisting of 19 barge-loads of 70 to 80 tons each, and containing, therefore, say 1,400 tons—chiefly of cattle-ship manure—was partly within 100 yards of a house. Some of this had been lying there for weeks, as shown by the growth of vegetation upon it.

Yet, at the wharf, a notice-board is put up, reading as follows :—

> "Notice.—The byelaws in force within the urban district of Milton require that manure deposited within 100 yards from any street, building, or premises in or on which any person may be employed in any manufacture, trade or business shall be removed within 48 hours. Neglect of the byelaws subjects the offender to a penalty of 5*l*. and a further penalty of 48*s*. for each day after written notice of the officer of the Sanitary Authority."

The proprietor of the cooperage, who lives at the adjoining house, says that in 1890, when an offensive cargo containing dead animals was unloaded opposite his house and workshop, about 30 yards from them, he and his wife and several of the coopers working for him suffered in health, having headache, sickness, and diarrhœa. His wife says that she began to be ill the same day that the manure began to be unloaded, and was ill a fortnight. Their house is old and in bad sanitary condition.

The Board received, on August 7th, 1890, a communication from Mr. Redgrave, Her Majesty's Inspector of Factories, drawing the Board's attention to the nuisance caused by the accumulation of barge-loads of manure on the wharves at Milton, which he considered to be offensive and injurious to the persons employed in the adjacent factories and workshops. He gave a list of eight such establishments, lying within range, according to the wind, of the nuisance at the wharves. He stated that, at his recent visit, at least 500 tons of manure had been lying there for some days, and that the stench was almost unendurable, so that, used as he was to the odours of manufacturing processes, it almost made him sick.

The Local Board have byelaws under section 44 of the Public Health Act, 1875, made in 1878 on the Local Government Board's model, but as it appears from their reported proceedings, they hesitate to enforce them, lest they should "drive trade away from the place."

Dr. Fisher, Medical Officer of Health, informs me that since my visit a stricter observation has been kept on the manure deposited at the wharf, and it has not been allowed to accumulate to the same extent, especially on the part of the wharf closely adjoining the cooperage.

Sittingbourne.

Much manure is also unloaded at a wharf on the opposite side of the creek, which is in the Sittingbourne Urban district. The Medical Officer of Health for Sittingbourne, Dr. Sutton, states in his annual report for 1889, that he has often traced enteric fever to London manure brought down for agricultural purposes in barges. He finds that the men who pilot these barges are often themselves sufferers, though their homes and surroundings are in good order.

Faversham.

Faversham, Kent, is also on a creek leading to the Swale. Dr. Boswell, Medical Officer of Health, informs me by letter that "a very "considerable amount of London manure, some of which is very offen- "sive, is landed at the town wharf (no part of which is more than

" 100 yards distant from houses) and carted through the town. The " major part of the manure business, however, is carried on at Oare " Creek, a part of the Faversham port, about a mile from the town " itself. We have some local restrictions on this business which also " apply to the business which is done in various forms of fish manure " which are also carted through the town.

" 1st. All such carriage of manure must take place before 8 a.m."

[In the present byelaws this rule has been dropped, but Dr. Boswell tells me that as a matter of fact the farmers adhere to the old practice. He says that no difficulty has been found in removing 60 tons or so of manure in two mornings before 8.]

" 2nd. Where the manure is of an offensive character it is to be covered with tarpaulins.

" 3rd. All such manure must be removed from the quay within 48 hours of its debarkation.

" 4th. Any droppings in the street from the carts carrying such manures are to be cleared up *at once* by the men attending the carts.

" I have been inclined," he says, " to attribute several cases of " diarrhœa—but after all only a very few—to the carriage of this " manure, but I am sure that since the introduction of rules for covering " the manure waggons, the nuisance has been much diminished. " Formerly one could smell the trail of the vanished cart for hours " after its passage."

" The men who work in the manure do not seem to suffer in health " at all. The dwellings situated around the quay where the manure is " landed, are occupied by the very lowest of our social strata, and among " them illness of all sorts is more prevalent than among their more " cleanly neighbours. Infantile diarrhœa is perhaps more common than " is desirable, but there were only two deaths from diarrhœa—one " infantile—in the whole town during 1891. Sore throat and diphtheria " are not more common in the neighbourhood of the quay than else- " where; diphtheria certainly is more prevalent in quite another district " of the town.

" On the whole," Dr. Boswell says, " I should say that under restric- " tions the nuisance of this trade may be considerably reduced, but this " is chiefly an agricultural district, and it has been a matter of some " trouble to get an assembly popularly elected to interfere at all. It is " perhaps possible that we are more able than other authorities to " exercise pressure, as there is an alternative, but more inconvenient, " quay at Oare, and the question of London manure is so constantly " discussed that consignees, feeling their tenure precarious, are very " manageable and conciliatory.

" With reference to byelaws, I am doubtful whether they do not " tend to restrict rather than to enlarge the powers of the sanitary " authority. The labelling of any unsatisfactory thing or con- " dition of things as a nuisance and injurious to health seems to me " practically to erect the sanitary authority into an absolute autocracy. " Of late years I have never met with any tendency to question the " right of the authority to do what seemed best in their eyes, merely " because it was necessary and apart from all reference to byelaws."

Ormskirk Rural District.

Ormskirk Rural District.—The following is from a report made by me in 1884, on the sanitary condition of the Ormskirk Rural District, Lancashire :—

" The soil, which is very fertile, is mostly cultivated in small holdings as market gardens; the great towns of Lancashire, to which

the district lies conveniently near, affording good markets for the produce, as well as furnishing the large supplies of manure which this kind of cultivation requires. Immense quantities of manure are brought by the Leeds and Liverpool Canal, which traverses the district in a circuitous course. These are a frequent source of nuisance in the villages by the canal, especially Maghull and Burscough Bridge. Besides stable dung, night soil, and house refuse, some of the manure contains fish refuse, slaughter-house garbage, and sweepings of markets, and much of it is very offensive. To some extent the nuisance is unavoidable, but it is increased—

"1st. By the manure being piled up in large heaps.

"2nd. By its being allowed to remain often several days before being removed.

"3rd. By the proximity of the wharves to houses and public places.

"When allowed to remain piled up in heaps the manure, especially if containing much vegetable matter, undergoes a kind of fermentation or putrefaction attended by heating, which greatly increases its offensiveness. The putting in force throughout the parts of the district near the canal of the byelaws for the prevention of nuisances might do something to mitigate the evil, either directly by enforcing speedy removal, or indirectly by leading to the provision of wharves in more suitable situations. Still in some instances grave nuisance has been complained of as being caused by the effluvia from these huge heaps of manure at a distance considerably greater than the 50 yards to which the operation of the byelaws before mentioned is limited, and some further provision or greater stringency of byelaw under section 44 of the Public Health Act, 1875, appears to be required in the district."

Nuisances from water-borne manure in the Samford and Maldon rural districts will be mentioned in other parts of this report. (See pp. 95 and 96.)

The Effect upon Health of Manure Nuisances.

Are manure nuisances injurious to health?

Difficulties of question.

The question whether, and if so to what extent, nuisances arising from the carriage of manure and town refuse free from human excrement* are injurious to health, is beset with difficulties like those attending similar questions with respect to other offensive businesses. On the one hand, we get from persons not connected with these businesses loud complaints of offence to the senses, and somewhat vague assertions of bodily discomfort and impairment of health; on the other hand, from people engaged in them and brought into close contact with

* Of the danger of town refuse which, like that of many of the Northern and Midland towns, contains human excrement there can be no question. The evidence is very strong that the specific infections of enteric fever and cholera find their opportunities of transmission among human beings mainly through the contamination by human filth of air, soil, and drinking water. Such contaminations are most potent for evil when taking place in and around dwelling-houses, the inhabitants of which are exposed to their evil influences for a large part of each 24 hours. But there is no reason to doubt that harm may be sustained by susceptible individuals by such briefer and occasional contact with contaminated air as they may be exposed to in the careless removal of excremental matters for use as manure.

One danger in the use of night soil as manure needs to be especially mentioned, viz., the contamination of water supplies where these are derived from the surface water off manured or cultivated ground. An outbreak of enteric fever ascribed to this cause was reported on in 1884 by the Medical Officer of Health for the Cowpen Urban District, Northumberland, and one in 1891 by the Medical Officer of Health for the Whitworth Urban District in Lancashire. Another outbreak of enteric fever seemingly due to this cause occurred in 1892 at Ashton-in-Makerfield, Lancashire.

the offensive materials, we often meet with stout denials that they ever experience any injury to health therefrom. It must be remembered, however, that those who work in manure are strong healthy men leading an active open-air life, that they are inured to the work by custom and reconciled to it by considerations of gain. Their escape from illness therefore does not prove the innocuousness of manure effluvia to persons of less powers of resistance. As a matter of fact, however, I do not believe that men working among manure invariably escape injury to health. I have formerly recorded* several instances in my own experience in which men who had been engaged in unloading cargoes of manure had contracted enteric fever, and have heard of similar cases in that of others (*see* pp. 82, 91, and 97 of this report).

Another difficulty in answering this question is, that several of the districts in which complaints of manure nuisances have been most rife are, from a sanitary point of view, ill-administered in other respects, so that it is difficult to eliminate the operation of other causes of disease.

What is "injurious to health"?

Dr. Ballard in his report on effluvium nuisances† has well pointed out that more than one definition of the term "injurious to health," and more than one criterion of such an influence being exerted, may be suggested:—

"(*a.*) It may mean that exposure to the offensive effluvia causes bodily discomfort or other functional disturbance, continuing or recurring as the exposure continues or recurs, and tending by continuance or repetition to constitute (though perhaps not a clearly defined form of disease) an appreciable impairment of general health and strength.

"(*b.*) Or it may mean that persons exposed to them are more deeply and more definitely damaged in health; that their lives are shortened or pursued in chronic ailment; that they are rendered more liable than other persons to the invasion of definite forms of disease; or that diseases are with them apt to run a less favourable course than with other persons."

Must be answered affirmatively.

It is, I think, clear that manure nuisances may be injurious to health in the first of these senses, and there is, I believe, some evidence to show that they may occasion graver injury in the second sense.

Diminution of comfort apart from definite injury to health is a ground for legal redress.

It would seem that according to legal decisions a person aggrieved by a nuisance arising from an offensive trade is recognised by the law as entitled to relief if injury to the extent of diminution of comfort be proved. *See* the case of Malton Local Board *v.* Malton Farmers' Manure and Trading Company, quoted in Dr. Ballard's Report, Part III. (Annual Report of Medical Officer of Local Government Board, 1878, pp. 316, 317). *See also* the case of Attorney-General *v.* Hussey reported in "Public Health" of August 1890. In the latter case an injunction was granted to restrain the defendant from burning bricks so as to cause a nuisance; and it was held, quoting the words of a former judge, that a nuisance does not necessarily mean that which is injurious to health, but that it must be "more than fanciful; more than one of "mere delicacy or fastidiousness; an inconvenience materially "interfering with the ordinary comfort, physically, of human "existence, not merely according to elegant or dainty modes and "habits of living, but according to plain and sober and simple "notions among the English people."

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* "Sanitary Record," May 17, 1878, page 314.

† Annual Report of Medical Officer of Local Government Board, 1876, Appendix page 117.

Modes in which injury to health may be produced.

The effluvia from decomposing organic matters, such as those of which manure is composed, may produce evil effects upon the human body in more than one way. Thus they may do so by obnoxious impressions upon the senses, especially that of smell, and through the senses upon the nervous system; or they may do so by the introduction into the body through the medium of the air of actually poisonous chemical matters or injurious micro-organisms.

In manure nuisances it is chiefly the stench, *i.e.*, the disagreeable impression upon the sense of smell, that is complained of. The mere offensiveness of a smell is not necessarily an indication of so serious danger to health as popular opinion would seem sometimes to suppose it to be. Certain odours sufficiently disagreeable, *e.g.*, those of a he-goat, or of burning soot, leather, or india-rubber, are not likely to be productive of serious disease. As a French proverb says: "Tout ce "que pue ne tue pas." Yet even such odours may, to persons in delicate health or of acute sensibility, occasion a considerable amount of discomfort, and by impairing appetite and otherwise, might, if persistent, produce deterioration of health. Still more is this likely to be the case with smells which, like those of putrefying animal matter, are not only disagreeable but disgusting to most persons of ordinary constitution. As the odour of carrion is attractive to the blowfly of which it is the natural food, so, on the other hand, the repulsiveness of this odour to human beings may be looked upon as a natural warning to them of the deleteriousness of the chemical products of decomposition of animal matter.

Dr. Ballard remarks (*loc. cit.*, p. 118) how often one particular group of symptoms is mentioned as resulting from exposure to offensive trade effluvia. This group consists of loss of appetite, nausea, sometimes actual vomiting, sometimes diarrhœa, headache, giddiness, faintness, and a general sense of depression and malaise. And he considers that as these symptoms may result from different kinds of effluvia, having nothing in common except their offensiveness, it is difficult to avoid the inference that the symptoms have their origin in the impression made on the senses.

The symptoms which in the course of my inquiries I have heard most frequently mentioned by persons who complained of being affected by manure effluvia are vomiting (frequently produced by sudden exposure to specially offensive effluvia), nausea, diarrhœa, sore throat (described by a medical man as "follicular tonsillitis"), loss of appetite, headache, and general feeling of weakness and illness. Some of these symptoms may be due to impression on the nervous system through the sense of smell; but others, as the diarrhœa and sore throat, would seem more likely to be due to the more direct action of deleterious matters, chemical or organised, taken into the body.

Incidental discomforts, occasioned by manure nuisances, are swarms of flies in hot weather, and of rats, and the necessity of keeping windows closed to prevent foul smells from coming into the house.

Diphtheria associated with manure effluvia:

Of graver and more definite forms of disease attributed to, or suspected to be produced by, exposure to manure effluvia the chief is diphtheria. A number of instances have been reported by skilled observers in which outbreaks of diphtheria in rural places, especially in the eastern counties, have been found to have been immediately preceded by the arrival of peculiarly offensive cargoes of London manure, to the effluvia from which the patients had been exposed.

in Samford Rural District, Suffolk;

Mr. Elliston, Medical Officer of Health for the Samford Rural District, Suffolk, reports an outbreak of diphtheria at Chelmondiston in that district in June 1889, following the landing of an extra putrid

cargo of London manure, to the effluvia of which, as it was carted through the village, the first three patients were exposed. He also reports an outbreak of scarlet fever in July 1889, at Stutton, of which the first cases occurred in two families in contact with a heap of London manure. Dr. Airy, in reporting to the Local Government Board on the outbreak of diphtheria at Chelmondiston, says that it is difficult to deny a certain weight to the considerations on which the earlier cases were ascribed by local belief to the malodorous traffic in London manure, especially as diphtheria has of recent years become increasingly prevalent in London. In view, however, of the existence, which he ascertained, of certain earlier cases of the disease in Chelmondiston, and of the difficulty of recognising diphtheria in its minor phases, he records the suggestion that the foul effluvia of the London manure may have operated to hasten forward the development of some home-growth of the disease, rather than to introduce it in its already full-grown form from the metropolis. Again, in October 1890, two or three cases of sore throat followed by a bad case of diphtheria occurred at Chelmondiston. Some large heaps of London manure had been allowed to remain uncovered on a field in the middle of the village.

in Chelmsford and Maldon Rural Districts, Essex;

Dr. J. C. Thresh, Medical Officer of Health for the Chelmsford and Maldon Rural Districts, has recorded in his annual reports, and in a paper read by him before the Society of Medical Officers of Health, and published in "Public Health," April 1891, a number of similar instances in which outbreaks of diphtheria or epidemic sore throat have occurred in association with the importation of London manure; the first cases being in persons in close relation therewith. He mentions, however, other instances in which outbreaks popularly attributed to London manure, were found on comparison of dates to have preceded its introduction, and he thinks that the connexion falls short of absolute proof.

Dr. Thresh has recently reported ("Practitioner," September 1892) another instance in which a sudden outbreak of diphtheria at Bradwell was at first ascribed to London manure, but the dates, when correctly ascertained, negatived this view. The cases of diphtheria had all occurred along the course of one road along which about four days before the outbreak offensive manure had been carted, or else in houses from which the children on their way to school would have to pass the place where the manure was deposited. It was subsequently found, however, that the manure in question consisted of "five-fingers" (star fish) dredged in the neighbourhood, and that the cargo of London manure which had arrived on the same day, and to which the outbreak was at first ascribed, had been sent away again to another place to be unloaded.

in West Kent combined districts;

Mr. Butterfield, Medical Officer of Health for the West Kent combined sanitary districts, has mentioned in his annual reports several instances in which outbreaks of diphtheria have been preceded by exposure to the effluvia of manure. I give one from his annual report for 1891, Maidstone Rural District:—

"Five members of a family residing in a cottage near Barming Bridge were taken ill with diphtheria at the time of the flood in October. No special unsanitary conditions were found on the premises. The mother attributed the illness to the stench from a barge which had been unloading London manure on the opposite bank of the river, which she described as being so bad as to compel her to keep her doors and windows shut. There had been no other case of diphtheria or sore throat in the neighbourhood and so far as I could ascertain, no possibility of infection."

On Manure Nuisances; by Dr. Parsons.

In June a mild case in Nettlestead was attributed to the effluvia from London manure.

Mr. Butterfield says, by letter, "I have often associated cases of diphtheria with manure nuisances, but it would be difficult to exclude other possible causes. I am inclined to believe that the effect of the manure in promoting the evolution of diphtheria is confined to houses in the neighbourhood of large accumulations, or in streets and lanes through which manure is frequently carted. I do not believe that by itself manure causes illness, but I have from time to time found outbreaks of diphtheria in the neighbourhood of accumulations of manure (stable and farmyard, as well as imported), and have formed the opinion that it helps along with other factors—season, dampness of dwelling, and the presence of the germ—to promote the spread and intensify the malignancy of diphtheria."

In Strood Rural districts;

An outbreak of diphtheria at Halling in the Strood Rural Sanitary District, Kent, in April 1887 was attributed by the Medical Officer of Health in part to the effluvia from a putrid heap of London manure containing slaughter-house refuse which had been spread on the land, and had caused a very offensive smell to pervade the neighbourhood.

In his annual report for 1889, for the East Ashford Rural District, Dr. Robinson mentions a solitary case of diphtheria which occurred in an out-of-the-way house at Challock. The sufferer was a young man who three days previous to his attack had been occupied in the removal of manure from a London barge, the smell of which was most offensive and penetrating.

The association of diphtheria with nuisances from town manure has been noticed in connexion with manure from other towns besides London. As already mentioned, it has been reported in the Hexham Rural District in connexion with manure from Newcastle, and in the Southwell Rural District in connexion with that from Nottingham.

In Guisborough combined district.

Dr. Stainthorpe, Medical Officer of Health to the combined Sanitary Authorities in the Guisborough Union, makes the following observations on this subject in his annual report for 1891 :—

> "In reporting to the Kirkleatham Sanitary Authority upon the three cases (in one house) occurring in their district in February, I stated there seemed to be some connexion between them and night soil brought from Middlesbro' by rail to the depôt at Kirkleatham crossing. On February 21st a consignment of night soil arrived at this depôt. On February 28th a child died from diphtheria after a few days illness; a fortnight later another child in the same house succumbed to the disease. Immediately before the development of the symptoms in the first child, both children, accompanied by their mother and grandmother, had, when out for a walk, passed the depôt when the grandmother noticed a foul smell which evidently proceeded from the night soil. The three cases at Brotton in October seemed also to be connected with night soil from Middlesbro'. The cases occurred in two houses widely separate and between which there was no communication. In one, the attack commenced on the 22nd, in another, on the 24th, and in the third, on the 27th. Night soil arrived at the Brotton depôt, which is in close contiguity to the passenger station on the 14th, and was spread over a field near the station. The person (an adult) who was attacked with diphtheria on the 24th had, on the 23rd, complained of a foul smell proceeding from this field. The other two patients resided at a farm a few fields away from that to which the night soil had been applied. In addition to these cases of diphtheria several others of sore throat existed about the same time, one of the patients being a railway official. It will be seen that of the 13 cases 11 occurred during the months of January,

February, March, October, November, and December, these months embracing the period during which night soil is most largely brought into the district.

"I have received several complaints of the nuisance arising from the unloading of night soil at depôts near passenger stations and dwellings, and the carting of it through streets during the day. That a serious nuisance and a danger to the public health is caused thereby I have no hesitation in saying.

"The value of the Middlesbro' night soil as a manure lies largely, I believe, in the blood and offal which it contains, and for this reason it is preferred by the farmers in this district to that collected in their immediate neighbourhood. It is these constituents which give it its frightfully sickening odour, and which probably also render it so dangerous, inasmuch as blood is one of the most suitable media for the growth and reproduction of disease germs. Moreover, germs which under their natural surroundings have only very slight disease-producing powers, may by propagation in such media as blood and offal, become virulent.

"So convinced am I of the danger surrounding the importation of town night soil into the districts that I strongly urge the various authorities in the union to form stringent regulations as to the distance of depôts from dwellings, the carting of it through streets during the day, and the placing of it on land near dwellings and highways."

The relation discussed.

The instances quoted seem to point to some relation between diphtheria and manure effluvia, but what that relation is cannot be stated. So much is still unknown respecting the causation of diphtheria, that it is impossible in any given case to state positively that all other possible causes have been excluded; and more especially, owing to the difficulty of diagnosing the disease in its mildest degrees, there is always the doubt whether it may not have been already present in an unrecognised form, when the manure incident supposed to have caused it occurred.

Another difficulty is that diphtheria is a disease of the country rather than of the towns, although in late years its fatality has increased in the latter; the relation is not likely therefore to be simply one of the conveyance of specific infection.

The following hypotheses may be mentioned:—

1. That the manure forms a specially favourable breeding ground for specific organisms already existing in it, or which have gained access to it.

2. That in localities where sore throat allied to diphtheria already prevails the inhalation of manure effluvia imparts to a comparatively mild affection a more definitely specific and severe character.

3. That the action of manure effluvia, like that of other septic effluvia, is to produce a non-specific sore throat, upon which the specific germ of diphtheria is more readily engrafted than upon a healthy mucous membrane.

Other diseases.

Of diseases other than diphtheria attributed to manure effluvia, I have mentioned elsewhere in this report a case regarded as puerperal septicæmia (p. 88), and a form of illness described to me under the name of "dumb ague" (p. 83).

Dr. Anderson, Medical Officer of Health to the Seghill Local Board, says in his annual report for 1891:—

"The most severe cases of diarrhœa occurred in the Station Rows, and were caused by Newcastle Corporation manure being emptied from waggons when in a state of acute fermentation in the months of July and August. I therefore reported this matter to the Local Board, and recommended its discontinuance at this place in such close proximity to dwellings. No deaths occurred at this place, but several of the cases were of the most serious character.

In his annual report for 1891 Mr. Adams, Medical Officer of Health for Maidstone, mentions three cases of enteric fever associated with the deposit and transit through the town of London manure; but he informs me by letter that these cases were by no means conclusively connected with the manure nuisance. In each case there was no discoverable sanitary defect or cause for the disease other than the complaint made by the patient of the nuisance in question; neither of them being intimately brought into contact with the manure. Enteric fever would seem less likely to be conveyed by London manure in which human excrement is only exceptionally present than by that of towns in which a "dry" system of excrement disposal obtains.

Enteric fever.

The contagia of other infectious diseases may be present in house refuse and manure containing it. An outbreak of scarlet fever in the Samford Rural District, thought to have thus originated, has been mentioned above. I formerly met with a case in which a signalman at a country railway station in Yorkshire was taken ill with small-pox. No other case existed in the district, and no source of infection was ascertained except that at a siding about 50 yards from his box a quantity of night soil and house refuse from Manchester, where small-pox was prevalent at the time, had been recently unloaded.

The Nature of Town Manure.

Composition of town refuse and manure.

The solid waste matters of a city or town are very various in character, but the kinds which are of importance in relation to this inquiry are the following:—

1. Human excrement.
2. House refuse:—Consisting of coal ashes, together with broken crockery, &c. (hard core), animal and vegetable refuse (soft core), and miscellaneous refuse.
3. Street sweepings.
4. Dung of horses and other animals. (The dung removed from cattle steamers will require special notice.)
5. Offal, or refuse of food materials:—Consisting of waste animal matters from slaughter-houses, unsound fish, poultry, &c., also vegetable refuse from markets, greengrocers' shops, &c.

Human excrement.

The mode of collection and the destination of these different classes of waste differ according to local circumstances. In London and other water-closet towns human excrement passes into the sewers, and is removed and dealt with as a liquid; but in towns in which a privy system exists it is dealt with as a solid, usually mixed with ashes and other refuse. Where the old-fashioned midden privy remains in use its contents do not undergo any kind of sorting beyond the occasional picking out of the coarser "hard core"; but where the pail-closet system is carried out, the excreta are often collected apart from the bulk of the dry refuse, and may undergo some preparation for the purpose of converting them into a manure more readily disposed of.

The disposal of excrement by so-called "dry" systems is a large subject, and I do not propose to enter into it in this report. The recent experience of several towns will be found in my report to the Local Government Board on "Slop-closets and Trough-closets," contained in the Annual Report of the Medical Officer for 1890. The tendency in many urban districts at the present time—a tendency based both on financial and sanitary considerations—appears to be to replace these "dry" systems by water carriage.

Domestic refuse.

In London where the house refuse is unmixed with excrement, and where owing to the mode of brickmaking in vogue there has been a

demand for the "breeze" or fine ash containing a proportion of combustible matter, a process of sorting has been and is still commonly carried out; though the lessened demand for breeze on the part of brickmakers, owing to the depression of trade, has of late years rendered it less profitable thus to deal with the refuse. In districts in which it has been found impossible to dispose of such refuse profitably, owing to the cheapness of coal, and the consequent large bulk and low value of house refuse, or to the lack of land in the neighbourhood on which it can be utilised, the custom has often been to tip it into some pit or waste ground. But this practice is objectionable in populous localities, and especially where the land may afterwards come to be built on; and it is also in many districts increasingly difficult to find tipping places. Hence in many such places destructor furnaces for burning up the useless rubbish have come into use. There is still the resulting clinker, amounting to about one-third the original weight of the refuse, to be got rid of. In the northern and midland towns, where red and blue bricks are used, it can be ground up for mortar making; but where light-coloured bricks are more generally used, such mortar, on account of its dark colour, is considered less suitable.

In London the removal of house refuse is undertaken or contracted for by the vestries as local sanitary authoritie. Formerly when breeze was more in demand for brickmaking, they were paid for the privilege of removing it, but now the removal costs considerable sums of money. In the main streets of the City of London the removal is effected daily, the dust being placed in movable boxes on the pavement and emptied direct into the dust-carts on their rounds. Fixed ashbins of brick or wood, of a size to hold the accumulation of a week or more, are, however, the usual arrangement in metropolitan districts; though movable bins of galvanized iron are now coming into use, and are to be preferred.

The sorting of the refuse, as commonly carried out in London, is performed by women, who, standing on the heap of ashes, sift out with hand-sieves the fine ash or breeze. The remainder is picked over: the cinders go, like the breeze, to brickmakers,* the paper, rags, string, bottles of various kinds, broken glass, scrap-iron and tin, corks, leather, oyster shells, &c., all find their appropriate uses. The "hard core" is used for foundations of roads; but its removal has to be paid for. The "soft core," consisting of animal and vegetable putrescible refuse, is either burnt in a destructor, or goes for manure.

Street sweepings.

3. Street sweepings (road drift) are removed by the local sanitary authority, usually with their own staff. They consist of a mixture of—1. Grit or mineral matter derived from the wearing away of the materials forming the surface of the roadways; 2. Horse droppings; 3. A certain admixture of miscellaneous rubbish, as paper, orange peel, and other vegetable refuse; 4. A variable proportion of water. The proportion of mineral matter varies according to the nature of the road surface; being greatest in the sweepings from macadamized roads, and least in those from asphalted or wood-paved streets. The water varies in amount with the

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* The breeze is incorporated with the clay of which the bricks are made; and as it consists partly of combustible matter, the bricks are thus made to contain their own fuel, the cinders being used underneath for lighting the "clamp" or pile of dry bricks. As both the breeze and the cinders contain organic matters which in burning give off an unpleasant smell, the business of brickmaking by this process is an offensive one. *See* p. 94, *and also* Dr. Ballard's report on Offensive Trades.

In other parts of the country bricks are burnt in kilns by means of fuel placed between and underneath them, not mixed into them, and the fuel is generally coal; so that the process is less offensive.

weather; so that the sweepings range in consistency from dry dust to liquid mud. The liquid renders the sweepings more difficult to handle, and has to be drained away as much as possible if they have to be be transported for any considerable distance. Road drift, though useful to lighten heavy clay soils, has little manurial value, as the horse droppings do not contain the urine which forms the chief channel of excretion of nitrogen from the animal body. The sharp sand washed out of the sweepings from flint roads is used for cutting marble. Road drift is often used for filling up pits and lowlying ground, and where it cannot thus be got rid of it has to be sent away by London vestries at a dead loss. It is not offensive, and indeed has in some degree the deodorant properties of earth: hence it may be usefully employed to cover up other and more offensive materials.

Dung of horses and other animals.

4. Stable manure, the dung of horses and other animals, has a market value, and is usually disposed of by private agency, either direct to market gardeners or through manure merchants, some of whom do business on an extensive scale. The value of stable manure is, however, less now than formerly, and fluctuates at different seasons of the year according to agricultural requirements and the farmer's facilities for disposing of it.

Stable dung varies in character according to the quantity and nature of the litter used. That from gentlemen's stables contains a large proportion of comparatively clean straw, but in stables of a poorer class litter is less abundantly used, and the manure consists chiefly of horse dung. Peat litter, sawdust, and shavings are not unfrequently used instead of straw. In mewses in which there are dwelling-houses the dung-pit serves as a receptacle for house refuse, and may even receive some human fœcal matter.

Stable dung, like other moist vegetable matter, undergoes, when piled up, a process of fermentation attended with evolution of heat, and ammoniacal vapour is evolved from the decomposition of the urine which it contains. The temperature attained may reach 120° F. The process begins in a day or two and lasts for several weeks; it is accelerated by dampness and close piling, as in underground pits, and is retarded, on the contrary, by dryness and exposure to the air. If the manure be disturbed in the active stage of heating it is very offensive, but when thoroughly rotten it has comparatively little odour. In a heap added to from day to day there will always be some portions in an active and offensive stage of decomposition.

The way to avoid nuisance from the accumulation of stable dung, therefore, is to remove it from the neighbourhood of dwellings at frequent intervals before the heating has had time to progress far, and in the meantime to keep it dry and exposed to the air. The best arrangement for this purpose is an iron cage standing under cover on a paved surface sloping to a drain.

Stable dung is sent out of London by road, by rail, and by barge. Market gardeners and farmers near London sometimes have contracts with parties keeping horses to take their manure all the year round at so much per load, or they purchase it as a perquisite from coachmen or grooms. The carts which bring agricultural produce to London take back loads of manure.

To more distant places manure is sent by barge, if near a river or canal; if not, it is sent by rail.

Cattle-ship manure.

The manure from cattle-ships is a peculiar kind, having a strong sour odour, as of fermentation, much more offensive than that of ordinary manure; and it is the source of much complaint at the riverside places to which it goes. Cattle are brought to this country from America in

large steamers. They are stalled in covered sheds fitted up on the upper and main decks, and are fed on the voyage on maize and on hay made of a coarse wiry grass, which also serves as litter. The manure is not removed during the voyage, but successive layers of litter are put over it; it contains more or less wasted maize, to the fermentation of which its pungent odour is probably due.

The importation of animals from foreign countries is subject to stringent regulations designed to prevent the importation of epizootic diseases. These regulations are contained in the Animals Order of 1886, made under the powers of the Contagious Diseases (Animals) Acts by the Privy Council, whose jurisdiction has been since transferred to the Board of Agriculture. Under this order foreign animals —the word "animals" including cattle, sheep, goats, and all other ruminating animals, and also swine—may be landed for slaughter in Great Britain only at ports having "Foreign Animals' Wharves," or "Landing Places for Foreign Animals." These ports are London, Bristol, Glasgow, Grimsby, Hartlepool, Hull, Liverpool, Plymouth, Portsmouth, Southampton, Barrow-in-Furness, Cardiff, and Falmouth; the foreign animal wharves at the three latter ports, however, are rarely used. Animals from abroad, except those from certain "free countries," must be landed at a Foreign Animals Wharf, and must be slaughtered within 10 days after the day of landing. Offal and manure can only be removed from a foreign animals wharf with the permission and under the direction of an inspector of the Board of Agriculture. Foreign animals from "free countries," if not intended for slaughter, must be landed at a Foreign Animals Landing Place, where they are detained for at least 12 hours, and then, if found free from disease, they may pass inland like home-bred cattle. Manure from Foreign Animals Landing Places is delivered out of charge, unless the animals have been found to be diseased.

The foreign animals wharf for the port of London is at Deptford, and is the property of the Corporation of London. The cattle steamers either discharge there, or more often are met in the river below London by a steamer, the "Racoon," belonging to the Corporation, which takes the cattle off to Deptford; and the cattle steamer then goes at once into dock, most commonly at the Tilbury, Victoria, or Royal Albert Docks, to discharge the rest of her cargo, to undergo cleansing, and to take in her export cargo.

The manure from cattle-ships is always discharged in dock into lighters or barges alongside, but it may not be removed from the dock except with the consent of the Customs, given upon the receipt of a certificate from the inspector of the Board of Agriculture at Deptford, testifying to the health of the cattle. The necessity of waiting for this certificate involves a delay in the removal of the manure. Until recently, in order for the Customs to pass the manure, it was necessary for the Board of Agriculture inspector to certify that the cattle were free from any disease. This could only be done after they were all slaughtered, as *e.g.*, the lungs had to be inspected for pleuro-pneumonia; and since ten days may elapse from landing, as above mentioned, before a cargo of cattle were all slaughtered, a delay undesirable in the interests of human health was thus apt to occur. Dr. Collingridge, Medical Officer of Health for the Port of London, informs me that in a crowded dock the close presence of the manure-laden lighters was often a source of great nuisance to other vessels. The delay would also permit decomposition to become further advanced, and thus increase the nuisance from the manure at its ultimate destination.

Professor Brown, of the Board of Agriculture, informs me, however, that arrangements have now been made by which this delay will be in great part avoided, as the Customs will now accept as sufficient a certificate from the inspector that the cattle are free from any disease capable of being conveyed by manure. The diseases of animals which are regarded as being capable of being conveyed by manure are, cattle plague, foot-and-mouth disease, swine fever, and sheep pox, and these can be detected without waiting for slaughtering. In the absence of any of these diseases the manure would be at once passed. In case of the presence of any of these diseases among imported cattle, Professor Brown tells me that their manure would not be detained in dock, but would be at once taken possession of by the Board of Agriculture, and destroyed at Deptford by mixing with its own weight of quicklime. This would prevent its being used for manure until decomposition was complete. In the last case which had occurred, a heap of manure so treated was kept for 12 months, and when removed was quite inoffensive. Such manure, however, would not be allowed to be used in agriculture, but would be taken out to sea and thrown overboard.

The Customs have power to prohibit the landing of manure from foreign cattle at any place on the shores of the United Kingdom; but not that of manure of home origin. This power of prohibition would probably be looked upon as having reference to the prevention of cattle disease, rather than of nuisance to human beings. The consent of the local authority under the Contagious Diseases (Animals) Acts,—*i.e.*, in boroughs, the Town Council, and in other urban or in rural districts, the Justices—is also required for the landing of manure from foreign animals.

The cattle-ship manure goes chiefly to Essex, and to Dartford, Greenhithe, and places on the Medway and Swale, in Kent; being conveyed in sailing barges, which bring back bricks or other cargo.

The manure from the cattle-ships is either put direct into the barges, or is thrown out into lighters, and thence transferred to the barges. (The difference between a barge and a lighter is, that the former carries a crew, who live for the time on board, whereas a lighter has no cabin.) This transhipment from lighter to barge, according to Dr. Collingridge, occasions an intolerable nuisance, if performed in dock, and he puts a stop to it there, causing it to be performed in the river near Barking, or requiring the sailing barges to be brought into dock, so that the manure can be put direct into them. No dock dues are payable on the barges; but the objection to loading direct into them is that it may involve the expense of keeping the crew, consisting usually of two men, waiting some days in idleness, whereas the lighters may be left without men. This objection, it may be expected, will be lessened by the altered practice of the Customs in passing the manure.

The cattle-ship manure is supposed to be disinfected by sprinkling it with a little lime, but neither Professor Brown nor Dr. Collingridge believes that, in the quantity ordinarily used, this has any appreciable effect even as a deodorant, still less as a true disinfectant. Dr. Collingridge would prefer that offensive cargoes should be covered with earth.

Offal.

5. Offal and garbage, *i.e.*, waste food materials, articles of food which have been spoiled by over-keeping, and the unusable portions of such articles removed in preparation for the table, form a very offensive class of refuse, both from the rapidity with which they become putrid, and from the offensiveness of the products of their decomposition. Substances such as form the food of man, in putrefying outside the animal body, pass through the whole range of chemical changes between the fresh

state and complete decomposition into stable and innocuous products; and in so doing they give off gaseous matters more or less offensive at almost every intermediate stage. On the other hand, when eaten, digested, and assimilated, they are partially burnt up within the animal body, and the residual matters, when excreted, are partly on their road towards complete decomposition, having already passed through some of the stages at which, in the course of putrefaction outside the body, offensive effluvia would have been given off. For this reason putrid animal tissues are far more offensive than excreted matters. It cannot, however, be affirmed that they are more injurious to health; for injury to health is caused not so much by impressions on the senses (olfactory or other), or by chemical products of decomposition, as by specific infection, which is more likely to be present in excreted matter than in dead animal matter, although should it be present the latter would form a favourable medium for its multiplication.

Waste food materials may be classified thus:—

(*a.*) Slaughter-house refuse.
(*b.*) Fish, game, and poultry offal.
(*c.*) Vegetable refuse.

From slaughter-houses

(*a.*) Slaughter-house refuse.—There are few parts of an ox, sheep, or pig which are not utilised in some way. Besides the edible portions of the carcase and viscera, the blood, bones, waste fat, hide, horns, hair, bladder, and guts all find their appropriate uses.* The portions which are not utilised, otherwise than in the crude state as manure, are the more or less digested contents of the alimentary canal, certain viscera, as the paunch or first stomach of the ox, and "slink" (fœtal) calves, together with a certain small quantity of blood and scraps.

Fish and poultry

(*b.*) Fish and poultry offal.—This consists of the inedible parts of fish, poultry, and game, and of fish and fowl which have gone bad and are not saleable. Fish and poultry soon become putrid, and game would not usually be thrown away unless it were already far advanced in decomposition. This class of refuse is very offensive.

Vegetable refuse.

(*c.*) Vegetable refuse from markets, &c.—Green vegetable refuse when undergoing decomposition in a moist state is offensive. This is especially the case with cruciferous plants, as the cabbage and turnip, and also with the onion and its congeners; all these plants containing essential oils which have sulphur as a constituent. Green refuse also heats rapidly, by which the offensiveness of manure containing it is increased.

In the passage of food materials to the consumer, the refuse has to be got rid of, so far as our present purpose is concerned, at three stages viz., first at the markets, where food substances are dealt in wholesale; second, at the establishments of retail dealers; and third, in the households of consumers.

Offal and food refuse from markets;

1st. The offal from public markets in London is dealt with by public bodies.

There are two cattle markets in London, viz., Deptford, for foreign animals as before mentioned, and the Metropolitan Cattle Market, Islington, for home-bred animals and those brought by land. Each of these cattle markets has in connexion with it a range of abattoirs, and at these abattoirs a large part of the slaughtering in London is done. A very large quantity of dead meat is brought into London, both fresh, and

* For these uses, and for the nuisances arising from them in the absence of due care, or to some extent in spite of all ordinary care, I refer the reader to Dr. Ballard's report on Effluvium Nuisances in the Report of the Medical Officer of the Local Government Board for 1876.

in the frozen state from abroad, so that the quantity of offal produced in London by no means corresponds with the quantity of meat consumed there.

The manure and offal from the Deptford cattle market is loaded day by day into barges alongside. It is treated with lime in the proportion of a pailful per cartload, or about 1½ tons to a barge-load, 100 tons, of manure; this is said to diminish stench. The manure was fetching at the time of my visit (December) 35*s.* per load of 100 tons. It is sent chiefly to places in Essex.

The Metropolitan Cattle Market, at Islington, is also the property of the Corporation of the city of London. I am informed by Mr. Hanman, market superintendent, that the whole of the manure and offal produced at this market is sold to one contractor, and is sent to places on the Great Northern Railway.

Killing takes place at Islington chiefly on Tuesday, Wednesday, and Thursday, in each week, little being done on Friday, Saturday, or Monday. The offal is sent away twice a week, Tuesday and Friday, in winter, and three times a week in summer. In the meantime it is stored on an open piece of ground near the slaughter-houses, where also the manure from the cattle pens is piled pending removal. It is sprinkled with carbolic acid in the proportion of about half a gallon to a ton of offal; this is said to be sufficient to keep it from stinking for a week. Anything specially offensive is buried in earth until it can be sent away, and when dug up is said to be found perfectly inoffensive. Diseased meat is saturated with carbolic acid, in order to render it uneatable.

The offal is taken to the manure siding at Maiden Lane, King's Cross, in the Corporation's carts and waggons. These are of wood and are not covered. The body of the cart is made to slide backwards and tip; so that when the cart is brought on to a raised platform and backed until the wheels are arrested by a plank at the edge, the whole contents of the cart are tipped at once direct into the railway truck. The railway company require the offal to be deodorised to their satisfaction, and with this view gas lime is used in the proportion of about 1 cwt. to a truck-load (8 tons) of offal. In loading the trucks a layer of long straw manure 6 inches thick is first placed at the bottom of the truck, to absorb liquid; a load of offal is then shot in and sprinkled with gas lime, and so on until the truck is full, when it is covered with another layer of long straw manure. The loading is not effected without some spilling of offal and draining of organic liquid on to the surface of the siding. At my visit, which was made in frosty weather, there was no offensive odour perceptible, but in hot weather it would doubtless be otherwise. There are, however, no houses very near the manure siding. The offal is said to be taken to somewhere near Peterborough, and to be buried until decomposed before it is put on the fields. I was assured that never more than two days would elapse between its being produced and its being unloaded from the truck at its destination.

The fish seized and condemned at Billingsgate Market, amounting to 90 or 100 tons per month, is taken possession of by the Fishmongers Company under their chartered rights, and is conveyed to Belvedere, Kent, where it is converted into artificial manure.

The putrid and diseased meat from Farringdon Market (the great market in London for dead meat) seized by the Commissioners of Sewers, which amounted in 1891 to 350 tons, is treated in their condemned meat shed. This is a shed with asphalte floor and white tiled walls, containing three large slate tanks, each of about 600 gallons capacity. These tanks are filled with a chemical solution in which the meat is steeped to deodorise it and render it uneatable. The liquid experimentally used at

the time of my visit was "Tuson's fluid," containing chloride of zinc and sulphurous acid. Usually the bath most relied on is one invented in 1877 by the Medical Officer of Health for the City of London, and consisting of chlorides of calcium and sodium, protosulphate of iron and picric acid; the latter being the only material found to stain the fat, which it renders of a deep orange colour.

The antiseptic properties of the baths are such that putrid meat is at once deodorised therein, and meat can be kept in for a month without becoming a nuisance. After steeping for a few hours the meat is delivered to a contractor at Bow, who pays a small sum for it, and is bound under penalty not to sell it as human or animal food. He renders the fat, and uses the bones and fibre for making artificial manure.

Putrid poultry and foreign game are similarly dealt with at Farringdon Market. Not much fish is sold at this market, so the amount of condemned fish is small.

The sweepings and refuse from the central markets in London, consisting of vegetable refuse, straw, paper, sawdust, &c., with a certain admixture of animal matters, are removed for the Corporation by the Commissioners of Sewers, and taken to their depôt at Letts's Wharf, Lambeth. Here the dry materials, such as straw, baskets, paper, &c., if not worth utilising, are burnt in a destructor. The soft core is mixed with offal from shops, horse droppings from street orderly bins, and road sweepings (which in the City consist largely of organic matter), and the mixture is sold for manure and barged down the river to places in Kent and Essex. The price it will fetch varies. Sometimes 3*l.* a barge-load is got for it; at other times it has to be given away for nothing.

I am indebted to Dr. Sedgwick Saunders for the above particulars.

The private slaughter-houses in London are, comparatively speaking, not very numerous. The offal from them is often removed together with stable manure.

from retail establishments;

2nd. The offal, food refuse, and broken food from retail establishments, such as butchers', fishmongers', poulterers' and greengrocers' shops, hotels, and restaurants, has, in part, a small commercial value, and such part of it is often collected privately for pig food, or for manure, or by rag and bone dealers.

Difficulty is often experienced in getting such stuff removed with sufficient frequency, as the private collectors do not care to call until a sufficient quantity has accumulated to make it worth their while to do so; and nuisance is apt to be created in the emptying of the vessels in which the refuse is stored and in the passage through the streets of the carts containing it.

Under section 33 (1) of the Public Health (London) Act, 1891, as under corresponding provision of previous Acts, the owner or occupier of any premises may require the Sanitary Authority to remove trade refuse, on payment of a reasonable sum for such removal; but there seems to be no power on the part of the Sanitary Authority to require trade refuse to be removed at frequent and regular intervals, though apparently if in any case it accumulated to such an extent as to appear to a sanitary inspector to be a nuisance, it might be required to be removed within 48 hours under section 35 (1) of the Act.

from private houses;

3rd. The animal and vegetable food refuse of private houses for the most part finds its way to the dustbin, and is the chief cause of the offensiveness of that receptacle. A better plan is to burn it in the kitchen fire, but this involves a certain amount of trouble which servants or housewives are not always willing to take. The difficulties are that in a modern close kitchen range there is little space above the fuel; and that to put on a quantity of wet green stuff slackens the fire and interferes with cooking operations. On the other hand, if the refuse be kept

until the cooking is over, when there is a smaller fire and more room in the grate, it is less readily consumed. These difficulties are successfully met by a little invention—Tupper's Household Refuse Destructor—upon which Mr. Gordon Smith and I have recently reported jointly to the Board. It consists of a small iron cage fixed in the kitchen flue just above the grate. It has in front a door, which falls forward to form a hopper, into which refuse, such as potato parings, cabbage leaves, &c. can be thrown as produced, and while the fire is hot, with as little trouble as into the ashpit; and they are gradually dried and consumed away, the ashes falling through.

In some households, however, waste portions of food are saved for pig-feeding, being collected from time to time by pig-keepers who come round for them. Such collections are apt to give rise to nuisance, as mentioned in Dr. Ballard's Report on Effluvium Nuisances, already referred to.

Carrion.

Carrion or the carcases of animals not used for human food may here be mentioned. Those of horses and asses are dealt with at knackers' yards, the different portions being utilised in various ways. The dead bodies of dogs and cats are often removed with stable manure or house refuse. The bodies of the dogs destroyed at the Home for Lost Dogs are disposed of for manure, and complaint has before now been made to the Board of nuisance arising when they have been used for this purpose in a populous neighbourhood.

Particular Methods of Disposal.

Methods of disposal at particular establishments:

The following are illustrations of the ways in which different classes of refuse are dealt with in practice at certain depôts visited by me in the course of this inquiry:—

Letts's Wharf.

I. *Letts's Wharf, Lambeth*, is the property of the Commissioners of Sewers for the City of London, and all the refuse of the City proper is brought there. Mr. Swales, junior, the superintendent, informs me that the matters dealt with are as follows:—

1. Street sweepings.—As the City streets are mostly paved with asphalte, wood, or granite setts, the sweepings contain a larger proportion of organic matter, and less grit than those from districts where the roads are chiefly macadamised.
2. Contents of street orderly bins.—These consist of horse-droppings, which are swept up as they fall by boys, and placed in tall bins standing on the kerb. The droppings being dry, and containing no urine, have little offensive smell; but a little "soft core" is mixed with them.
3. Market sweepings from Smithfield, &c., consisting of straw, sawdust, cabbage leaves, and such like, also a small quantity, about a load a day, of refuse from Billingsgate Market, consisting of sweepings, with a certain amount of waste fish.

   [The above are all mixed at the wharf by being thrown together into barges alongside. The manure is sent to farmers in Kent and Essex.]
4. House refuse, &c.—There are few fixed dustbins in the City, the ashes and dust being stored mostly in movable boxes. In the main streets these boxes have to be placed on the pavement before 8 a.m., and are emptied each morning into the dustcarts which perambulate the streets daily. In the side streets the dust is called for and is collected at any hour of the day.
5. Trade refuse.—This is collected with the house refuse, but its removal has to be paid for. It consists largely of packing materials from warehouses and shops, *e.g.*, paper, straw, boxes,

and baskets. Much of the offal from fishshops, restaurants, &c. is collected privately for use as pig food, manure, fat rendering, or other purpose, and does not come to Letts's Wharf.

The house refuse is sorted, mostly by women and girls, who stand sieve in hand on the heap and sift the fine ash or "breeze" from the coarser materials, picking out from the latter and throwing into separate baskets such as are capable of utilisation. The destination of these is various; rags, string, and the best pieces of paper go to paper-makers; mineral water bottles are sold to a "Mineral Water Bottle Exchange Company," who return them to the manufacturers whose names they bear; wine bottles to bottle dealers; medicine bottles to people who wash them and sell them at the doors of hospitals for the use of out-patients; miscellaneous bottles to proprietors of shooting galleries; white glass to glass makers; green bottle glass to makers of emery paper; scrap iron, tinware, and other metal to dealers in old metal. Corks are ground up to make floor cloth. Old boots contain pieces of leather which can be used again. Even oyster shells find a use, being ground up to make shell gravel for canaries and poultry. The breeze is sold to brickmakers. The "hard core" is used for filling in foundations of new roads, but is of so little value that its removal has to be paid for; as has also that of the clinkers from the destructors in which is burnt the worthless part of the rubbish remaining after the sorting.

The work of sorting the refuse by hand is a repulsive one, as the women stand deep in the ash heap and become begrimed with dirt. They do not, however, consider it unhealthy; several whom I spoke to appeared robust, and said that they rarely or never suffered from illness except their somewhat numerous confinements. Mr. Swales gave me a table showing the result of inquiries which he had made in October 1888, of the women dustsifters as to the illnesses from which they had suffered. The table contains the names of 49 women of ages from 17 to 65 years. These had been employed at Letts's Wharf for periods ranging from 1 month to 21 years, or on an average $9\frac{1}{2}$ years, besides in many instances at similar work elsewhere, making a total average of 14 years. 30 of them had had children, the total number of children being 200, or an average of 6·6 children each. Of the 49, 41 stated that they had had no illnesses, apart from childbirth; 4 had suffered from accidents, 1 from "brain fever," 1 from "pleurisy," 2 (including one of those who had met with an accident) from "debility," and 1 from "pains across the stomach, six weeks."

Probably, however, none but robust women would engage in such an occupation.

Refuse Disposal Co.

II.—*At the works of the Refuse Disposal Company* at Chelsea, where the dust collected from the parishes of Kensington, Chelsea, and Westminster is disposed of, no women are employed, and the sorting is done chiefly by machinery. The carts on arrival are tipped direct into a large revolving wooden screen with 3-inch spaces. This is boxed in, and connected with a fan which draws off the flying dust to the hearth of the furnace. A "worm" or spiral partition inside the screen carries the coarse matters which will not pass through the spaces to the far end, where they are picked over by hand; such as are of any value are separated, and the remainder ground up under edge runners.

The finer materials which fall through the first screen are carried by an elevator to a second revolving screen of $1\frac{3}{4}$-inch mesh. Here the ashes and breeze fall through, the paper is blown out by a blast of air, and the coarser matters fall on to a revolving table, where they are picked over by boys, any saleable materials separated, and the rest ground under the edge runners. The ground material is carried back to the first screen. The separated paper and other suitable materials

are made into brown paper on the premises. The ashes and breeze which pass through the second screen are carried by a travelling endless band to a third screen of $\frac{3}{8}$-inch mesh, by which the fine ash, constituting two-thirds of the bulk, is separated for the use of brickmakers. The breeze is burnt in a furnace with the aid of forced draught from the fans, and supplies steam for the working of the machinery. In summer the finest ash, under $\frac{1}{8}$ inch, is sifted out for the use of makers of blood manure, but there is no demand for this in winter.

In the present works, which are somewhat of an experimental character, the "soft core," which is the offensive part of the house refuse, is ground up small and goes with the fine ashes and breeze, but it is admitted that this destination is objectionable, as it heats and adds to the offensiveness of brick burning; and it would be better if it were sorted out and either burnt or put with manure.

III.—*The Manure Depôt of the Newington Vestry, Manor Place, Walworth.*. Newington Vestry Depôt.

The Newington Vestry make the collection and manipulation and disposal of refuse a large business, to the details of which their vestry clerk, Mr. L. J. Dunham, to whom I am indebted for much information, acts as manager. This business is carried on mainly on commercial principles, but I am assured that the sanitary aspect is not lost sight of.

The Newington district in South London, having no river frontage, being surrounded on all sides by other populous districts and being remote from any open country, the problem before the Vestry was how economically to get rid of the street sweepings, which, as many of the streets are macadamised, are considerable in amount. This problem they have endeavoured to solve by mixing them with stable manure purchased for the purpose, and selling the mixture.

The Vestry have a large town depôt in Walworth, crossed by the viaduct of the London, Chatham, and Dover Railway, on to which trucks can be raised by a hydraulic lift. They have also country depôts at Meopham and Longfield, and have recently purchased one at Sevenoaks; all these places being in Kent and adjoining the London, Chatham, and Dover Railway.

The stable dung is fetched by the vestry with their own waggons, and they pay large horseowners for the privilege of removing it. Small owners, such as costermongers who keep a pony or donkey, bring manure and deposit it at the depôt without payment. The manure is used to make dams to retain the liquid road slop until the watery part has drained off. The two materials are mixed together and the mixture is allowed to remain in heaps until heating is over, when it is put into trucks and sent away by rail to farmers or to the country depôts.

This practice involves the retention in the centre of a dense urban district of a very large quantity of manure in the heating stage. The quantity varies from time to time according to the time of year and the character of the season—wet weather preventing its removal on to the land. At the time of my visit on January 6th, 1892, there were 4,000 or 5,000 tons in stock, but I have been informed that the quantity has since been much reduced.

The Medical Officer of Health, Mr. Millson, however, informs me that no complaints of nuisance from the depôt have been received by him, nor has he been able to trace any excess of fever or other sickness in its neighbourhood as compared with the rest of the parish. The immediate neighbourhood of the depôt is mostly occupied by yards, &c., and the nearest row of houses is 62 feet distant from it. It is considered that the admixture of the road drift diminishes the offensiveness of the

manure, and also that less nuisance is created by leaving the manure undisturbed until the heating is over, or nearly so, than by removing it when hot.

Little fish offal, slaughter-house offal, or vegetable refuse comes to the depôt. Such as is received is stated to be at once placed in trucks and sent away to the country.

The household dust of the parish is also collected by the Vestry, and brought to the depôt, where a portion of it is sifted by hand in the usual manner to sell. The valueless dust is sent by rail to shoots at Longfield and Sevenoaks at a cost of 1*s.* 8*d.* per ton for carriage, and 2½*d.* per ton for unloading. Screened ashes from Longfield depôt are supplied to brickfields lower down the line.

The total amount of stuff dealt with by the vestry from Newington alone is at present about 45,000 tons a year, for a population of 115,663. In addition to this the vestry also received up to March 1892 the refuse of the parish of St. George's, Southwark ; but this arrangement has now been terminated.

As regards the cost of disposal (apart from that of collecting) the vestry clerk gave me the following return :—

Vestry, St. Mary, Newington.

Return showing the actual Receipts and Expenditure attending the disposal of House Refuse and Road Sweepings, and the Loss arising thereon, for the year ending 25th March 1890.

House Dust.

Receipts.	£	*s.*	*d.*	*Expenditure.*	£	*s.*	*d.*
Amount received from Wandsworth Board -	200	13	11	Screening - - -	833	0	8
Sale of 12,165 tons -	1,497	5	9	Loading into trucks -	142	19	6
Trade refuse - -	41	2	8	Railway carriage on 17,456 tons - -	1,663	18	10
Sale of rags, bones, &c. -	34	3	7	Unloading dust at Longfield - - -	71	19	2
*Balance against - -	1,829	16	1	Commission on sales -	92	8	10
				Proportion of establishment charges - -	798	15	0
	£3,603	2	0		£3,603	2	0

*Or 2*s.* 2*d.* per ton loss.

Manure Mixture (*i.e.*, Road Sweepings, &c.).

Receipts.	£	*s.*	*d.*	*Expenditure.*	£	*s.*	*d.*
Sale of 21,236 tons -	3,144	6	4	Loading into trucks -	261	4	8
Rent, Meopham land -	5	0	0	Unloading at country depôts - - -	52	3	4
*Balance against - -	1,443	11	3	Railway carriage on 21,190 tons - -	2,201	0	7
				Commission on sales -	176	19	4
				Stable dung - -	932	11	1
				Proportion of establishment charges - -	968	18	7
	£4,592	17	7		£4,592	17	7

*Or 1*s.* 4½*d.* per ton loss.

Summary.

	£	s.	d.
Loss on house dust - - -	1,829	16	1
Do. mixture - - - -	1,443	11	3
Interest on capital - - -	1,440	0	0
	£4,713	7	4

Or a loss of 2*s.* 5½*d.* per ton on 38,646 tons, including interest on capital.

L. J. Dunham,
Vestry Clerk.

Vestry Hall, Walworth, S.E.,
15th April 1891.

Questioned as to the advantage of purchasing manure to mix with the road sweepings, if the mixture had to be sold again at a loss of so much per ton upon an increased tonnage, he replied that it enabled the road sweepings to be better dealt with, and got rid of with some return, whereas otherwise they would have to be sent out of the district by rail at a dead loss, which he estimated at 3*s.* 6*d.* per ton, as follows :—

	s.	d.	
Railway carriage - - -	1	8	per ton.
Unloading carts and levelling trucks -	0	0½	,,
Labour for banking slop - -	0	1	,,
Loading into trucks (when sufficiently dry) - - - - - -	0	3	,,
Unloading at shoot - - -	0	2½	,,
Establishment charges - - -	0	6	,,
	2	9	
Interest on capital expended - -	0	9	
	3	6	per ton.

(irrespective of value of shoot).

During the year ending March 1891, 11,000 tons of manure were bought, and 33,000 tons of mixture were sold. Disregarding the manure brought to the yard free of cost (against which would have to be set the diminution in the bulk of the road slop through the draining off of the liquid parts) this would leave 22,000 tons as the amount of road sweepings to be got rid of. A loss of 3*s.* 6*d.* per ton on 22,000 tons would amount to 3,850*l.*, whereas a loss of 1*s.* 4½*d.* per ton on 33,000 tons would amount to 2,268*l.* 15*s.* 0*d.*

The Storage and Transport of Manure considered with a view to Prevention of Nuisance.

Storage and transport of manure.

In the preceding pages we have considered the nature and origin of the materials which constitute the solid refuse of a town, and more especially of such as, without any process of manufacture, go direct to the land as manure. The course of such materials from their place of production to their final application to the land may usually be divided into the following stages, viz. :—

Stages.

1. Storage where produced.
2. Collection and carting to wharf.
3. Carriage by rail or barge.
4. Unloading at wharves.
5. Storage at wharves.
6. Carting from wharves.

7. Storage on land.

8. Application to land.

[Some of these stages, however, may be omitted in certain cases, as in that of the manure collected by market gardeners from stables and carted direct to the land.]

At each of the above stages nuisances and dangers to health may arise.

Storage where produced.

1. The storage of putrescible matters in the place of production is probably the stage at which they are most likely to be deleterious to health, for the reasons that the storage often takes place near to dwellings, the inmates of which are thus exposed to the influence of the products of decomposition continually and not merely occasionally; and that, as there is reason to think, it is in a comparatively early stage rather than in the later stages of decomposition that injurious products are most apt to be formed.

The question of the prevention of nuisances from accumulations of organic refuse at the place of production is a wide one, embracing indeed a large part of sanitary administration, but it hardly comes within the scope of this report to consider it further than to remark that the general principles to be had in view are to remove all such refuse from the neighbourhood of dwellings at the most frequent practicable intervals, preferably daily; and in the meantime to store it at a sufficient distance in watertight receptacles of a capacity no greater than necessary, and having a smooth and non-absorbent surface; the contents being kept dry by the exclusion of rainfall, of ground moisture, and as far as possible of admixed liquid, and by the use of suitable absorbents.

Ample legal powers for the carrying out of these principles as regards excrement, house refuse, manure, and slaughter-house refuse are given as regards extra-metropolitan districts, by various sections of the Public Health Act, 1875, and by the byelaws which may be made thereunder. For London analogous powers are given in various sections of the Public Health (London) Act, 1891.

Collecting and carting through town.

2. The collection and cartage through London (which usually takes place in uncovered carts) of household refuse, manure, and food refuse occasions a certain amount of nuisance, varying with the nature and staleness of the materials and the state of the weather. This might be prevented so far as the cartage is concerned by requiring the carts or vessels to be covered, and by arranging that this traffic shall take place under due control at hours when the streets are less frequented.

Section 16 (2) of the Public Health (London) Act, 1891, requires that the County Council shall make byelaws inter alia (*a.*) for prescribing the times for the removal or carriage by road or water of any fœcal or offensive or noxious matter or liquid in or through London, and providing that the carriage or vessel used therefor shall be properly constructed and covered so as to prevent the escape of any such matter or liquid and as to prevent any nuisance arising therefrom.

Byelaws for this purpose are now under consideration.

To Urban Sanitary Authorities outside of the metropolis the power to make similar byelaws is given by section 44 of the Public Health Act, 1875, and more explicitly by section 26 (1) (a), (b), and (c) of the Public Health Acts Amendment Act, 1890, where this latter Act has been adopted. The making of byelaws under these sections is permissive and not compulsory as in London.

To Rural Sanitary Authorities urban powers under these sections may on their application be granted by the Local Government Board, and such Authorities are then able to make similar byelaws.

3. Manure is removed out of London by rail, and by barges on the river and canals. It is also conveyed by road to market gardeners and farmers within a comparatively short distance of London ; the waggons which bring agricultural produce often carrying back manure. The passage of these waggons along the streets occasions, as already remarked, a certain amount of nuisance. I have not heard any complaints of nuisance from manure in its actual transit by rail or water, except where the trucks or barges have been detained close to houses or to other vessels.

Carriage by rail, water, or road.

4. The unloading of the manure at the wharves or sidings to which it is consiged occasions, on the other hand, nuisances of a very grave character for which it is difficult to find a remedy. The time occupied in loading and on the journey, usually greater in the case of a barge than of a railway truck, allows the manure to become heated, and any animal refuse which it may contain to pass into an active state of decomposition; so that the process of unloading, which is done by manual labour, is an extremely offensive one. Any superficial application of deodorants would be useless, as each stroke of the dung-fork exposes a fresh surface of manure, and scatters the offensive vapours into the air. On the other hand, any application at the time of loading of antiseptic or deodorant chemicals in quantity sufficient to retard putrefaction or to deodorize the entire mass would be out of the question on the ground of expense, and would probably deteriorate the value of the manure. The only available means therefore of lessening the offensiveness of the manure on its arrival seem to be to shorten as much as possible the time in transit, and in loading to mix specially offensive materials with cheap deodorants such as lime, earth, charcoal, or road grit. A certain degree of offensiveness, however, appears inevitable, and if it affected only those who voluntarily engaged in the handling of the manure would hardly afford ground for interference with a necessary trade, unless the evidence of injury to health were very cogent.

Unloading at wharves occasions grave nuisance.

The chief ground for complaint, however, with reference to the unloading of manure is the unsuitable positions of the sidings and landing-places at which it is unloaded, which are often close, and sometimes most objectionably so, to public thoroughfares and inhabited buildings. Many examples will be found in an earlier part of this report, the most extreme instances being perhaps Swanley Junction (page 80) and Greenhithe (page 87).

Besides the offensiveness of the act of unloading, the filth-sodden condition of the ground at wharves where manure is habitually unloaded occasions a permanent nuisance of a serious kind. The spilling of a certain amount of manure is inevitable, and the spilled manure gets ground up by cart wheels and washed in by rain. Liquid filth dropping from the manure as it stands in trucks on the sidings also soaks into the earth, which is thus rendered black and offensive.

Difficulty of prevention.

The only effectual remedy for nuisance at this stage, as it appears to me, would be to forbid the unloading of manure within a certain distance of inhabited buildings, and I would suggest the distance of 100 yards as a reasonable one under ordinary circumstances, though I do not think that it would in all cases be sufficient for the prevention of nuisance. A distance of 100 yards from any inhabited building is commonly fixed in byelaws made under the second part of section 44. Public Health Act, 1875, as that within which any transported filth must not be allowed to remain for longer than a specified period (usually 24 hours), unless effectually deodorised.

[It is to be observed that a byelaw forbidding the deposit of manure near inhabited buildings for more than a specified time

is of no use towards the prevention of the nuisance now under consideration, viz., that which arises during the act of unloading. This may be very grave, although the manure be at once conveyed away, and not suffered to remain on the wharf at all.]

Serious as is often the nuisance from unloading of manure, much difficulty is experienced in bringing to bear upon it the powers for the abatement of nuisances conferred by the Public Health Act, 1875. This difficulty arises from the following proviso to section 91 of that Act, "Provided:— "first, that a penalty shall not be imposed on any person in respect "of any accumulation or deposit necessary for the effectual carrying on "any business or manufacture, if it be proved to the satisfaction of the "court that the accumulation or deposit has not been kept longer than "is necessary for the purposes of the business or manufacture, and that "the best available means have been taken for preventing injury to the "public health thereby."

Although the quantity of manure at an unloading place may at any given time, or at all times, be very large, yet if it be taken away as fast as it comes, so that no one portion remains more than a short time, it is often held that the exemption quoted applies, and that there is no ground for proceeding either against the owner of the manure or the persons bringing it.

Can unloading of manure be prohibited at places where it causes nuisance?

How far this is correct in law I am not competent to say; but the following instances seem to show that Sanitary Authorities are not entirely powerless under these circumstances.

Case at Burnham.

Dr. Thresh states that on his advice the Maldon Rural Sanitary Authority in 1889 prohibited the unloading of manure at a wharf in the middle of the village of Burnham. The ground for this advice was that outbreaks of diphtheria had from time to time occurred in Burnham, which were so closely associated with the unloading of London manure at this wharf as to raise in his mind a strong suspicion, and in that of the local medical men, a decided opinion, that they were due to it as a cause. During the three years since this prohibition was carried into effect only a single case of diphtheria, and that an imported one, has occurred in the village, whereas 10 deaths from diphtheria and 5 from membranous croup had occurred in the two years, 1888-9, before the prohibition.

As regards the legal authority for this prohibition Dr. Thresh writes: "When I entered upon my duties here I found the unloading of manure "already prohibited *during the summer months*. There had been no "case of diphtheria, so far as I know, during the summer; but directly "after the first load came in the autumn cases occurred, and I went "over to investigate the cause. As the result I recommended the "Authority to make the prohibition absolute at Burnham, as the manure "could just as easily be landed either above or below the village. Our "power to do so was doubted; but I pointed out that if they could "prohibit it during the summer months, they could do so during the "winter also. The feeling was so strong in Burnham, and among the "members of the sanitary committee, that they issued a notice saying "that anyone unloading manure in the village would be prosecuted for "causing a nuisance. I expect we should take proceedings under "section 91, Public Health Act. But we never anticipated any trouble, "and have had none."

At Chartham.

In another case the Bridge Rural Sanitary Authority successfully prosecuted the South-Eastern Railway Company for a manure nuisance at Chartham Station.

Respecting this case, Dr. Robinson, Medical Officer of Health for the East Kent combined sanitary districts gives me the following particulars.

"The nuisance was occasioned by fish manure placed in trucks and unloaded at a siding of the South-Eastern Railway, at Chartham, in the Bridge Rural Sanitary District. Whenever the Inspector of Nuisances complained, the specific loads were removed, and the nuisance was thus abated, but only to recur at irregular intervals. The Sanitary Authority therefore not only laid an information for an offence committed upon a certain day, under section 91, 38 & 39 Vict. c. 55. but proceeded also under section 96, for a prohibitive order against the use of the siding for deposit and unloading of manure, and the Justices made this order so as to prevent a recurrence of the nuisance. The order was obeyed, and no appeal was made by the Company."

From a sanitary point of view it certainly seems that there should be legal power either to prohibit generally the unloading of offensive and noxious matter within a specified distance of inhabited buildings, or to prohibit the unloading of manure at any particular place where it has been proved to give rise to nuisance.

There are, no doubt, obstacles to forbidding by general enactment the unloading of manure within a specified distance of houses. Thus:—

(*a.*) A hard-and-fast rule might be difficult of application. A distance, for instance, which in one case was not more than sufficient, might in another be unreasonably great.

(*b.*) The vested interests and statutory objections of railway companies and others could with greater or less force be pleaded against uniform legal enactment.

(*c.*) Prohibition everywhere of the use for manure purposes of a wharf or siding within a definite distance of dwelling-houses, could with some show of reason be resisted, unless erection of dwellings within a like distance of any already established wharf or siding devoted to the manure business were at the same time prohibited.

Perhaps the end in view might be sufficiently attained by means of byelaws, which, while embodying principles might permit of modification in satisfying the different (and legitimate) local requirements of one and another district. In this connexion I cite certain byelaws recently drafted by the Board's legal adviser, to meet the wants of a particular district.

"No person shall unload or deposit within 100 yards from any street, or from any building used for human habitation or as a school or place of public resort, or in which any person is employed in any manufacture, trade, or business, any filth emitting a stench, and brought to the place of unloading or deposit for the purpose of being removed therefrom.

"Every person who shall unload or deposit any filth emitting a stench, and brought to the place of unloading or deposit for the purpose of being removed therefrom, in any place within such a distance from any building used for human habitation or as a school or place of public resort, or in which any person is employed in any manufacture, trade, or business, that the stench is likely to cause offence to the persons in such building (although such place be not within the distance of 100 yards from such building shall) cause such filth to be forthwith covered with a sufficient layer of earth, or other suitable substance, or shall adopt such other precautions as may be sufficient to prevent the emission of any noxious or offensive effluvia from the filth."

But in the event of the regulation of manure traffic being left to be dealt with by byelaw there will be need for the Central Government to be empowered to require sanitary authorities to make byelaws in this subject-matter if it should see fit to do so. At present the Board has no such function, nor does the Board of Trade, as I learn from Sir C. Boyle,

possess any power under which they can govern the action of railway companies in receiving, conveying, and delivering manure of which they are the carriers. And if the Local Government Board is to regulate sanitary authorities in the above sense, it is obvious that the Board of Trade should at the same time be empowered to regulate railways and other carriers of manure and other filth.

Regulations of railway companies as to manure traffic.

In reference to this part of my subject, I have been in correspondence with the goods managers of the principal railway companies running out of London as to the precautions taken by the companies themselves to avoid nuisance from manure traffic. Their replies are to the following effect:—

South-Eastern.

South-Eastern Railway.—Mr. Light, goods manager, writes:—

"As regards ordinary stable manure we have not any special regulations, taking it for conveyance all the year through.

"For animal or fish refuse we have special regulations, as shown by the form of consignment note which I send you herewith."

No. _____

SOUTH-EASTERN RAILWAY.

Consignment Note for Manure, containing or consisting of Animal or Fish Refuse.

The South-Eastern Railway Company hereby give notice that they decline to accept for conveyance, from the 1st July to the 30th September inclusive, consignments of manure, loose, or in bags, casks, or other receptacles, consisting of or containing animal or fish refuse. From 1st October to the 30th June inclusive, the Company will accept such manure traffic for conveyance, providing it is fresh and entirely free from offensive odour, upon sender prepaying carriage and signing the undertaking at foot, authorising the Company to sell or otherwise dispose of the manure, if not removed by Consignee within six hours after the arrival of the consignment at the station of destination, and agreeing to defray the Company's charges, and all expenses incurred by the sale.

To the South-Eastern Railway Company,

Receive and forward the under-mentioned consignment on the conditions named herein.

_____ Station. _____ 188 .

Owner and No. of Truck.	Consignee.	Address.	Station.	No.	Description.	Weight.				Paid.			By whom received.	Remarks.
						Tons.	Cwts.	Qrs.	Lbs.	£	*s.*	*d.*		

In the event of Consignee neglecting to remove, or refusing to remove, this consignment within six hours after arrival at the station of destination, I hereby authorise the South-Eastern Railway Company to sell, bury, or otherwise dispose of the whole of the manure, or such portion of the whole as may be remaining upon their premises at the expiration of the time before mentioned, and to apply the money arising from such sale, if effected, in satisfaction of their charges for freightage and the costs and expenses incurred by reason of such sale or other disposal, the Company undertaking to pay over to me the balance, if any, after such charges, cost, and expenses as aforesaid have been deducted, and I further agree to pay to the South-Eastern Railway Company any money that may be due in respect of their charges, costs, and expenses, in the event of their having by the sale, or by otherwise disposing of the manure, failed to recover sufficient money to meet the said charges, costs, and expenses.

Witness { *Name* _____ / *Address* _____ / *Date* _____

Sender's or his Agent's Signature. { *Name* _____ / *Address* _____ / *Date* _____

London, Chatham, and Dover Railway.—The regulations in force with reference to manure containing or consisting of animal or fish refuse are similar to those on the South-Eastern Railway.

L. & S.W.R. *London and South-Western Railway.*—Mr. Owens, goods manager, writes:—

"The company does not undertake the loading or unloading of manure. We have no special regulations in force as regards its carriage, but we have, during the summer months, stopped its transit to certain suburban stations."

L.B. & S.C.R. *London, Brighton, and South Coast Railway.*—Mr. Staniforth, goods manager, says:—

"I am not able to furnish you with copy of any general instructions relating to the conveyance of manure on this railway. Extending over a number of years there have been many letters written by my department to the company's station-masters and others, concerning precautions necessary to be taken for the prevention of nuisance, but these letters had bearing upon circumstances arising out of the season of the year, the particular description of the manure conveyed, or the exceptional conditions applicable to particular stations. Further than this, we have had correspondence at various times with our agents at London stations upon the importance of only inoffensive manure being accepted by us, and the strict measures to be enforced in respect to certain dealers suspected of surreptitiously covering up unwholesome matter in trucks ostensibly loaded with stable manure.

"The directions given by me to station-masters at stations where residential property adjoins the station have been to use their best efforts to secure the removal of manure at times when the least nuisance was likely to be created, and to use such influence with consignees as they are able to this end. The company is, however, very much in the hands of the consignees in this matter, being bound to fulfil their obligations as common carriers, but nevertheless find general willingness on the part of the consignees of manure to study the circumstances of any particular locality."

G.W.R. *Great Western Railway.*—Mr. Wilkinson, chief goods manager, says:—

"The company have no separate regulation to govern the loading, conveyance, and unloading of manure traffic.

"A fractional part of the manure traffic dealt with upon the company's system is no doubt in certain circumstances and at certain seasons of the year of a disagreeable character, and in cases coming under this category, where they are established, we exercise our common law rights, and decline to carry. This has in the past been found sufficient.

"In certain cases of a doubtful character we have objected to receive manure traffic upon Saturdays, because we have known that in regard to such consignments there has been considerable risk of their being kept on hand at the receiving stations until Monday."

L. & N.W.R. *London and North-Western Railway.*—Mr. Harrison, chief goods manager, informs me:—

"There are no special regulations of a general character. The traffic, so far as this company is concerned, principally consists of stable manure. I presume your inquiry refers more particularly to the removal of night soil, and I may say that this is not forwarded frequently from places on this company's railway, and generally the loading is performed during the night."

Midland R. *Midland Railway.*—Mr. Adie, goods manager writes:—

"With respect to the loading, unloading, and carriage of manure, I beg to inform you that we have no special printed instructions upon the subject, of which I could send you a copy, but it is our practice to deal with the traffic as promptly as possible, and where we are required to place waggons for the purpose of its conveyance into the agricultural districts, sidings are used—as far as it is possible to arrange—away from the passenger stations or dwelling-houses, in order to obviate to the greatest possible extent any unpleasantness arising from it.

"At our London stations, where the greater portion of this traffic is dealt with, strict instructions have been given by my directions to supervise as carefully as possible the loading of it, in order to prevent the introduction of fish offal and other obnoxious matters."

Great Northern Railway.—Mr. Twelvetrees, chief goods manager, says:— G.N.R.

"We have no written or printed regulations as to the conveyance of town manure, but at various periods have had strong complaints from the local authorities as to the offensive smell at some of our stations.

"So far as King's Cross is concerned we keep a very sharp watch on the loading of manure, and prohibit the loading of slaughter-house offal, fish manure, or such like offensive matters.

"At one or two of our Lincolnshire stations we have had complaints from the passengers of the offensive smell of manure, where dealt with in sidings contiguous to the passenger stations. In these cases we have minimised the complaints by having the waggons unloaded as far away from the passenger stations as possible."

It will be seen from page 105 that the above statement has to be qualified in so far that the company receive at their manure siding at Maiden Lane, King's Cross, offal from the Metropolitan Cattle Market, though they will not receive it except from the Corporation of London, and they require it to be deodorised to their satisfaction. I saw a notice on a board as follows:—

"Great Northern Railway. Manure traffic.—Notice is hereby given that any person or persons loading into the company's waggons fish offal, animal matter, decayed vegetables, or other refuse likely to create a nuisance, will be prosecuted as the law directs.

"By order."

I was informed that before any truck was loaded with offal the company required a consignment note to be placed on it, and ascertained by telegraph that a siding at the place of destination was clear for its reception. These precautions do not apply to ordinary manure.

Great Eastern Railway.—In an interview which I had with an official of the goods department of this line, he stated that great quantities of stable and other kinds of manure were conveyed thereon. There were no special regulations, except as to fish manure. This latter is not conveyed during the summer months (May 1st to August 31st). In the remaining months it is conveyed under special conditions as follows:— G.E.R.

"Whereas the consignor hath applied to the company to carry for him from time to time consignments of fish for manure. And whereas the company refuse to carry fish for manure, on account of its offensive smell, except under the special conditions herein-after set forth. It is witnessed that the consignor and the company hereby mutually agree as follows, viz.:—

"1. The company shall from time to time during the continuance of this agreement carry for the consignor fish for manure; provided that the same shall not be consigned to places beyond their own system of railways.

"2. The fish for manure shall in all cases be loaded by the consignor in such part of the station or stations or other places whence the same shall be consigned as the company shall direct, and in such a manner and at such times as not to cause any annoyance or nuisance to the passengers by the company's railway.

"3. The consignee shall unload every consignment of fish for manure as early as possible after its arrival and at such a place in the station as the company may direct, and in such manner and at such times as not to cause any annoyance or nuisance to the company's passengers, and in default of his doing so the consignor shall indemnify the company against all loss, costs, damages, and expenses which the company may sustain in consequence thereof. If in the judgment of the company's station-master for the time being any consignment of fish manure is a nuisance to the passengers using the line of railway, or to the public generally, the station-master may at once order such manure to be disposed of by way of sale or destroyed, such sale or destruction to be made by the company at the cost of the consignor, who shall upon demand repay them their costs of sale or destruction. In case of sale the amount realised by such sale less any outstanding charges due from the consignor shall be paid to the consignor.

"4. All consignments of fish for manure, whether 'carriage paid' or 'carriage to pay,' shall be carried at the expense of the consignor, and the charge for the carriage and all other charges, if any, upon every consignment (unless the same shall be tendered by the consignee at the time of receiving the consignment), shall be paid by the consignor on demand.

"5. Every consignment of fish manure under this agreement shall be carried at the sole risk of the owner, except that the company shall be liable for fraud or the wilful act or wilful default of their servants, if proved, and in case the consignor shall not be the owner, the consignor shall indemnify the company against all claims to be made by the owner arising otherwise than from such fraud or wilful act or wilful default of the company's servants, if proved as aforesaid, and against all costs, charges, damages, and expenses in anywise resulting otherwise than from such fraud or wilful act or wilful default of the company's servants as aforesaid.

"6. This agreement shall continue in force until 30th April 18 , unless it shall be determined prior to that date by one party giving to the other of them one week's notice to that effect.

In witness whereof the said
and two of the directors of the company, on behalf of the company have hereunto set their hands the day and year first above written.

Witness

Fish manure is conveyed only from Stratford and Devonshire Street stations and goes to various places. It is collected by dealers from fish shops, and the quantity of it is not very large. The company have not received many complaints of nuisance from manure traffic; those that they have had have come chiefly from suburban residential places, and mostly when slaughter-house offal has been mixed with the manure. Station-masters have a discretionary power to refuse or deal with any offensive matter. The manure is conveyed in ordinary trucks which are not covered nor water-tight. There would be great difficulty, I am informed, in keeping special trucks for manure traffic, unless they were only used to ply between particular stations, as it is not the custom to keep a record of the whereabouts of individual trucks so long as they are on the system of the railway company owning them.

From these replies it appears that the offensiveness of the manure traffic and especially of offal and fish refuse is recognised by railway

companies and that some precautions are taken to prevent its becoming a nuisance. The success will no doubt largely depend upon the care with which they are carried out: it does not seem to have been greatest on those lines which have on paper the strictest regulations. Among the instances mentioned in an earlier part of this report of nuisances from railway traffic in manure it will be observed that in respect of the best appointed and best managed railways, few complaints as to manure nuisances have been made, or if any have been, effectual steps have been taken to remedy them.

Storage at wharves.

5. Storage at the place of unloading takes place chiefly in the case of manure brought by water to wharves which belong to private owners. Here the manure may lie awaiting the convenience of the consignee to fetch it away. Or the manure may be the property of a dealer, and may lie on the wharf until he can find a customer for it. In the early stages of decomposition when the manure is actively heating, it is very offensive, especially if disturbed when hot, and may occasion great nuisance to persons living near; but when decomposition is complete it is comparatively inoffensive. It has then, however, lost its offensiveness through having meanwhile given off the ill-smelling and noxious volatile products of decomposition into the surrounding air.

There would appear to be no legal difficulty in dealing with a nuisance of this kind. An accumulation or deposit which is a nuisance or injurious to health comes within section 91 (4) of the Public Health Act, 1875, and in this case it cannot truly be pleaded that the deposit has not been kept longer than necessary for the purposes of the business. It also comes within the scope of byelaws which may be made in an urban district under section 44 of the same Act, for the prevention of nuisances arising from filth, dust, ashes, and rubbish. The byelaws (7 and 8) in the Board's Model Series on this subject, which have been largely adopted by sanitary authorities, provide that the owner or consignee of any cargo or load of filth (or any person who may have undertaken to deliver it to him), conveyed by land or water to any place in the district and deposited to await removal, without adequate means of preventing the emission of stench therefrom, within a specified distance (usually 100 yards) of any street or inhabited building, shall not allow such filth so to remain without reasonable excuse for longer than a prescribed period (usually 24 hours). [Neglect on the part of the owner of the wharf at which the manure is allowed to lie may not seem at first sight to be provided for, but I am informed by the legal department that he may be considered a person who has undertaken to deliver the cargo to the consignee.]

Some difficulty may occasionally arise from the words "without reasonable excuse" being interpreted with undesirable latitude. The reason, however, why deposits of manure are allowed to remain in objectionable proximity to houses (*e.g.*, at Dartford, p. 90, and Milton, p. 91, at each of which places I found hundreds of tons of manure which had been lying for lengthened periods within 100 yards from inhabited buildings, the distance specified by the byelaws locally in force), is not that there is not legal power to forbid such storage, but that local authorities are disinclined to put in force the powers which they possess, for fear of injuring trade or private interests.

Cartage from wharf.

6. The cartage of manure along the streets and public roads from the place of unloading to that of its use on the land is another frequent source of complaint. This is based partly upon the stench emitted from the uncovered contents of the carts as they pass along, but chiefly from the manure, owing to defective construction or careless loading of the carts, being allowed to drop on the highway, where it is permitted to

remain, and is ground up by the passing traffic, so that the road surface remains long polluted by it.

There is really no excuse for nuisance of this kind, which is due simply to the carelessness of carters, the parsimony and inconsiderateness of farmers, and the apathy of local authorities. For the removal a properly constructed cart should be used, and for material which is wet and sloppy, a watertight one. The cart should be carefully loaded, and, if the height of the load renders it necessary, should have boards round the sides to prevent any of the material falling off. Any that falls off should at once be swept up.

As a covering to prevent droppings and confine the stench, a good tarpaulin securely tied on is usually sufficient, except in the case of liquid matter.

Byelaws with the above objects may be made by any urban authority, or by any rural authority invested with the requisite urban powers. They may be made under two enactments, viz., Part II., section 44, Public Health Act, 1875, or section 26, Public Health Act (Amendment) Act, 1890. The former enactment applies to "filth, dust, ashes, and rubbish," the latter to "any fœcal or offensive or noxious matter or liquid."

Byelaws on the Board's Model, under section 44, Public Health Act, 1875, are in force in a large number of districts.*

The only point of which I have heard complaint as to their inadequacy is that the cart is required to be "furnished with a sufficient covering "so as to prevent the escape of the contents thereof," whereas it is held that the emission of stench should be also, as far as practicable, prevented. A similar limitation is also made in the Act of 1890. From a chemical point of view, no doubt, the giving off of effluvia is "the escape "of the contents," but it is doubted whether it would be so held in a court of law.

In populous districts it is often found desirable to limit the hours during which offensive matters may be carted through the streets in order to avoid the most frequented hours of the day. Byelaws for this purpose may be made under each of the above-mentioned clauses of the Acts of 1875 and 1890. On the other hand, removal during the night is open to the objection that the work cannot be efficiently superintended, and hence that there is risk of dropped matter being allowed to remain on the roads.

The hours usually sanctioned by the Local Government Board are 6 to 8.30 a.m. in the summer, from March to October inclusive, and 7 to 9.30 a.m. during the winter, from November to February inclusive.

[In the special case of Southend, however, where grave nuisance existed from unloading of manure on the foreshore, byelaws have been sanctioned restricting the unloading and carting of manure to the hours of from midnight to 8.30 a.m. throughout the year. The byelaws in question were made under a local Act of 1875, which empowered the Southend Local Board to make byelaws with respect to the landing and carting of manure for the comfort and convenience of the inhabitants. It was shown in this case that the landing could only be effected at certain states of the tide, and that the hours ordinarily fixed would not afford sufficient time for the work, and the Local Board undertook to arrange for the necessary supervision.]

Storage on land. Application to land.

7. Storage on the land, and
8. Application to the land.

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* The Board have also sanctioned in a good many district, byelaws under the Act of 1890, based on a model published by Messrs. Knight & Co.

An objectionable practice is common in country districts of piling manure in large heaps on waste ground by the roadsides, or in fields just within the gate, and close to the highway, to await distribution over the land. Though unpleasant to the passers-by, this practice is not generally much complained of unless the manure is of a specially offensive character, or is placed near to houses. The spreading of manure of an offensive nature over the land in the neighbourhood of houses may also occasion nuisance and be dangerous to health.

The means of preventing nuisances of this class are simple, viz., to deposit the manure at a sufficient distance from public thoroughfares and houses, or to cover it with a layer of earth; and, after spreading it on the land, to plough or dig it in without delay. Farmers, however, not themselves objecting to the smell of manure, are often unwilling to depart from their usual practice in deference to what they consider the fastidiousness of their neighbours.

The following byelaw of the Board's Model Series II., under section 44, Public Health Act, 1875, aims at the prevention of certain graver nuisances of this kind in urban districts:—

> 10. Every person who, for any purpose of agriculture, shall deposit or cause to be deposited upon any lands or premises within the distance of—(usually 100 yards)—from any street, or from any building or premises used wholly or partly for human habitation, or as a school, or as a place of public worship, or of public resort or public assembly, or from any building or premises in or on which any person may be employed in any manufacture, trade, or business, any filth which may have been removed from any cesspool, or any filth which may have been removed from any privy, or from any receptacle used in connexion with any privy, and which may not have been effectually deodorised, shall, with all reasonable despatch, cause such filth to be ploughed or dug into the ground or to be covered with a sufficient layer of earth, ashes, or other suitable substance, or shall adopt such other precautions as may be reasonably necessary to prevent the emission of noxious or offensive effluvia from such filth.

This byelaw only applies to human fœcal matter, and is therefore of no avail for the prevention of nuisances from London manure. If legal considerations permitted I think that it might reasonably and usefully be extended to include certain other specially offensive and dangerous classes of material, such as fish refuse, slaughter-house offal, and other dead animal matters. I understand, however, that such matters are excluded from this and the other byelaws of this series in view of the terms of section 44. This empowers an urban authority to "make byelaws for the prevention of nuisances arising from snow, "filth, dust, ashes, and rubbish, and for the prevention of the keeping "of animals on any premises so as to be injurious to health." Dead animal matter has not been considered to be included in these words; as I learn from the legal department that the Board have taken the view that the word "filth" means fœcal matter, human or animal. Thus byelaws under this section, so far as they apply to London manure, do so in virtue of the comparatively inoffensive, and not of the most noxious, of its constituents.

The scope of the byelaws which may be made under section 26 (1) of the Public Health Acts Amendment Act, 1890, is wider in so far as it includes "any fœcal or offensive or noxious matter or liquid;" but the objects for which byelaws may be made are limited to (*a*) prescribing the times for the removal through the streets of such matter or liquid; (*b*) for providing that the vessel, &c. used for carrying them shall be properly constructed, and covered so as to prevent the escape of such matter or liquid; and (*c*) for compelling the cleansing of any place on which such matter or liquid may have been dropped during

removal. As these objects may all be provided for as regards "filth" in byelaws made under the earlier Act, the only point gained by making byelaws under the Act of 1890 seems to be the regulation of the carriage of such offensive matters, *e.g.*, dead animal matters, as are not legally included in the term "filth."

The Board usually recommend that stable manure should be exempted from the provisions of byelaws made under section 26 of the Act of 1890, on the ground that it is comparatively inoffensive. It should, however, be understood that the exemption only applies to horse-dung mixed with litter only. Much of the manure which is sent out from London and other large towns, while consisting in the main of horse-dung, contains also such offensive materials as fish refuse, slaughter-house garbage, and other putrid animal matter, and it is clear that such matters should not be exempted from the provisions of the byelaws even when mixed with horse-dung.

Summary.

Summary.

1. The manure traffic, although lawful and necessary in the interests of both town and country districts, often occasions serious nuisances and sometimes injury to health.

2. The diseases which have been thought capable of being produced or conveyed by town manure are :—

1. General malaise, vomiting, diarrhœa.
2. Sore throat (follicular tonsillitis).
3. Diphtheria.
4. Enteric fever (when human excreta are contained in the manure, and especially when water sources are contaminated by it).
5. Other infective fevers.
6. Septicæmia, &c.

3. Although London manure is practically free from human excrement, yet much of it is of a very offensive character, largely due to its containing food refuse and waste animal matters, and to the length of time occupied in its transit.

4. The principal nuisances arising from the manure traffic in the districts to which it is consigned are caused by :—

(*a.*) The unloading of trucks and barges in improper situations, as near houses or in frequented places.

(*b.*) Deposit and storage of manure near houses.

(*c.*) Careless carting, allowing effluvia to escape and the manure to drop on the highways.

(*d.*) Careless disposal of manure on land near houses.

5. To a great extent these nuisances already are under the control of local authorities through the provisions of the Public Health Acts, or through byelaws which may be made thereunder; but in agricultural districts and small market towns there is often an indisposition on the part of local authorities to exercise the powers which they possess for their repression.

6. The directions in which further legal powers appear desirable are :—

(*a.*) An extension of the scope of byelaws under section 44, Public Health Act, 1875, to include putrescible refuse matters other than fœcal.

(*b.*) The power, if it do not already exist, to prohibit the unloading of manure in the immediate neighbourhood of inhabited buildings, either generally within a specified distance, or in any particular instance upon proof of nuisance.

APPENDIX B.

No. 1.

Further Report on the Pathology and Etiology of Diphtheria; by Dr. Klein, F.R.S.

App. B. No. 1.

On the Pathology and Etiology of Diphtheria; by Dr. Klein.

I.—*The relation of Diphtheria to Membranous Croup.*

In his Milroy Lectures, 1891,* Dr. Thorne Thorne draws attention to the difficulties which in clinical, etiological, and pathological respects at present beset the definition of what is and what is not true diphtheria.

> "Inquiry (says Dr. Thorne) into the causes of diphtheria
> " prevalences elicits few things more striking than the ever-
> " recurring need of an attempt to disentangle the beginnings
> " of an epidemic from out of the midst of a group of affections
> " which, in so far as nomenclature is concerned, have but little in
> " common."

Divers manifestations of diphtheria.

And it must indeed be clear to everyone who studies in the reports of the medical inspectors of the Local Government Board the records of various diphtheria epidemics, that cases of croup, of laryngitis, of tracheitis commonly occur, sometimes even in groups, simultaneously or antecedently to prevalences of unmistakable membranous diphtheria of the fauces; cases, that is, which, but for their association with unmistakable diphtheria, would have passed as simple non-diphtheritic throat malady. There can be, I think, very little doubt in the mind of anyone who reads the reports in question, and accounts also of many similar occurrences in England and on the Continent, that there occur cases of membranous croup of the larynx and trachea unquestionably associated with, and indeed derived from, membranous diphtheria of the tonsils and the pharynx. But there are nevertheless cases of membranous croup of the larynx and trachea which seemingly are not connected as regards time and place with diphtheria; cases in which there has not been seen during life, and at the post-mortem examination there has not been found, any condition of the fauces that would imply that they were in a true sense diphtheritic.

Accordingly, the question which in clinical, etiological, and pathological respects is at present still involved in great difficulty is this:—

Are or are not such cases diphtheria?

For answer to this question it is necessary to be able to accurately define what is and what is not diphtheria.

Various definitions of diphtheria.

Since Bretonneau laid down the clinical and pathological definition of diphtheria, sanitarians and pathologists have learned that there exist a good many cases of undoubtedly infectious diphtheria not covered by

* Diphtheria: Its Natural History and Prevention.

Bretonneau's terms; cases in which there is at no time membrane or ulceration to be observed in the organs of the throat. Thus, amongst the many examples that can be adduced for illustration it will be sufficient to quote Dr. Thorne Thorne's experience at Great Coggeshall in 1876*:

> "Following on the series of 'croup' attacks, a second group of "somewhat similar sort had commenced during the second week "of January, but in two out of the three later fatal attacks the "diagnosis was 'diphtheria and croup' And lastly, simple "'diphtheria,' or that disease associated with paralysis, was "recognised both in the fatal and non-fatal form. Seven more "deaths took place before the middle of March. Then ensued a "large number of attacks which were in the main regarded as "'sore throat' only, and this, although an infectious quality in "the disease seemed indicated by the number of instances in which "attack succeeded attack in the same household. Two fatal "attacks in this group were registered as having been due to "'diphtheria.' Between the beginning of May and the end of "August the disease greatly abated, only 18 mild cases of throat "illness being recorded. But a rapid spread commenced in "September, although between the 1st of that month and October "30th only 2 deaths occurred out of 54 attacks that were heard "of. These 2 deaths were admittedly due to well-marked "diphtheria, whereas many of the other cases would have passed "all but unnoticed had it not been for the sustained inquiry that "had been set on foot. Between the beginning of November and "the end of the third week of December fatal attacks were more "largely interspersed with the milder cases of throat disease; and "the outbreak appeared to come to a close with 3 fatal diphtheria "attacks in the last 10 days of December, when a serious milk-"epidemic of enteric fever set in. The total attacks of throat "disease in a population of some 3,300 had been 170, and of these "25 terminated fatally."

A further proof of the difficulty of accurately defining what is and what is not diphtheria, is afforded by those cases of scarlet fever which are followed by a condition spoken of by some as "diphtheritic" throat, but by others denied as in any real sense diphtheria. It must be evident, therefore, that from a clinical point of view the term "diphtheritic" refers to diverse and ill-defined conditions of the upper air passages having not necessarily more than a single manifestation in common, namely, the presence of a "membrane." The pathologist, however, is somewhat in advance of the physician in this matter, inasmuch as he gives from his view-point a more reliable definition, with corresponding better means of diagnosis, of disease of this sort; though, as we shall see, pathologically also a good deal of uncertainty and divergence of view still prevails.

Virchow.

Virchow first grouped the inflammatory changes of mucous membranes into (*a*) catarrhal, (*b*) fibrinous, and (*c*) diphtheritic; and most pathologists have accepted this classification, adding, however, several other differential characters. Thus Weigert,† after very carefully conducted experiments, divides the fibrinous change into a croupous or purely fibrinous, and into a pseudo-diphtheritic exudation; the former differing from the latter in the fewer leucocytes present in the exudation. In

Weigert.

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* Milroy Lectures, pp. 45 and 46.

† Virchow's Archiv, Vols. 70 and 72.

the present day, however, the "fibrinous" inflammation of Virchow and the croupous and pseudo-diphtheritic change of mucous membrane of other writers, is held to be that condition of the membrane consisting of more or less laminated (under the microscope, reticulated) exudation of fibrin *on the surface of the mucosa*, which, though itself inflamed perhaps and denuded of its surface epithelium, does not become in any way necrosed. True diphtheritic change of mucous membrane, on the other hand, is regarded as involving *exudation into the mucosa itself;* a condition resulting —under engorgement and stasis in the vessels of the mucosa,—*incomplete necrosis* of that tissue. In these latter circumstances the mucosa becomes in effect diphtheritic membrane; its superficial part contains leucocytes, its middle or main part is a reticulated fibrinous necrosed tissue, while its deeper part—that in contact with the inflamed but still living portion of the mucous membrane—contains, like this latter, leucocytes. Most text-books now represent the above anatomical conditions as differentiating "croupous" and diphtheritic change of mucous membrane. These definitions of throat affections do not, however, bring into account "sore throat," "follicular tonsilitis," "pharyngitis," &c., in which there is no distinct formation of "membrane"; nor do they necessarily include post scarlatinal changes of the fauces, in which a mucous membrane previously ulcerated as a result of scarlatina subsequently exhibits formation of "membrane."

Later views.

It is, I think, almost universally accepted,—indeed there are at present very few dissentient voices,—by all who have any considerable experience of the bacteriology of diphtheria that the Klebs-Löffler bacillus, which acts virulently on guinea-pigs is the true *bacillus diphtheriæ;* that it is constantly present in enormous numbers in the superficial parts of the diphtheritic membrane in the acute cases of diphtheria, and in no other disease; that as time passes the number of these bacilli in the membrane decreases; and that as the mucous membrane gradually recovers itself the bacilli ultimately disappear. I myself have so far examined over 40 cases of true membranous diphtheria of the fauces. The membrane was obtained by me within the first three or four days of its appearance, and invariably I have succeeded in finding in it an abundance of the true bacillus diphtheriæ, by examination of cover-glass specimens, as well as by culture on gelatine and on agar, and by injection of sub-cultures into guinea-pigs. The experiments detailed by Dr. Sidney Martin in another report in this volume show this bacillus diphtheriæ to be beyond doubt the cause of diphtheria. He proves by the physiological action of the chemical toxic substances obtained by him indifferently from the tissues of diphtheria patients, from the diphtheria membrane in their throats, and from culture media in which bacillus diphtheriæ had been grown, that Löffler's contention respecting this bacillus being the real cause of diphtheria is out of question correct. And this proof having been afforded, it becomes important, in regard of any given case in which the clinical observer or the pathologist is hesitating as to nomenclature between croup simple and croup diphtheritic, to inquire whether the bacillus diphtheriæ is or is not present in the throat exudation. For if this bacillus be present the diagnosis must needs be diphtheria.

The Klebs-Löffler bacillus the *vera causa* of diphtheria;

Judged by this standard, let us inquire what has been the experience of other observers with reference to the diphtheritic nature of one and another malady presenting manifestation of throat mischief suggestive of diphtheria. Though the number of cases subjected to skilled bacteriological scrutiny in this respect has not been great, yet the cases on record constitute an important body of evidence.

Its presence diagnostic of the disease;

Löffler hereon.

Löffler (Mittheilungen aus dem Kaiserl.-Gesundheitsamte, II., p. 439 and following pages) details five cases of scarlatina with "diphtheria," in four of which the bacillus diphtheriæ was absent. The single case in which these bacilli were demonstrated differed markedly, as regards his anatomical description of it, from the other four, and was undoubtedly a case of diphtheria. It was a girl, four years and five months old, who sickened with scarlatina upon which, after a few days, diphtheria supervened. On the 10th day of her illness masses of diphtheritic membranes which had formed in the pharynx became loose, *but were soon however formed again.* Löffler's cases of *true* diphtheria of the fauces, with or without extension of membranes into the larynx and trachea, need no comment; they appear in every respect typical, and in all the membranes harboured the characteristic bacillus of diphtheria. He mentions, however, a case (Case 12) that is specially interesting in this connexion. It was that of a child one and a half years old who sickened with the symptoms of pneumonia, and died on the third day. On post-mortem examination there was found pneumonia of both lungs, with pseudo-membranes in the trachea; but the fauces and pharynx were quite free of membrane. The "membrane" of the trachea, nevertheless, contained the diphtheria bacilli. This is, in Löffler's series, the only diphtheria case which was not associated with diphtheria membrane of the fauces or pharynx, and which accordingly might clinically and anatomically have been designated "croup"; and the more easily since on microscopic examination (*ibidem*, p. 444) the condition of the mucosa was not found that of typical diphtheria, but such as is ascribed to croup; at any rate to that form of croup which Weigert calls pseudo-diphtheria.

Babes.

Babes (Wiener Klin. Wochenschrift, 1889, No. 14) likewise found the bacillus diphtheriæ only in those cases of scarlatina in which, in their later stages, there had occurred secondary true diphtheritic membrane. In his experience the ordinary so-called diphtheritic change of the throat occurring *during* scarlatina was not associated with the bacillus diphtheriæ. To the same effect are the observations of Kolisko and Paltauf (Wiener Klinische Woch., 1889, No. 8). They found the bacillus diphtheriæ in all cases of croup, whether associated with diphtheria of the fauces or pure croup of the larynx and trachea; as also in all cases of diphtheria occurring as a sequel to scarlatina, measles, and enteric fever. But they invariably missed these bacilli in the cases of so-called diphtheria complicating acute scarlatina.

Holzinger and others.

Holzinger (Inaugural Dissert., Munchen, 1889) mentions that Escherich found the bacillus diphtheriæ in only two out of seven cases of scarlatinal diphtheritis. A similar result is described by Wurtz; and Bourger (Arch. de Méd. Experim., 1890, No. 3), while failing to find the bacillus diphtheriæ in nine cases of so-called concurrent diphtheria and scarlatina, did find it in two cases in which the diphtheria followed the scarlatina 7 and 38 days respectively afterwards. Lastly, Tangl (Zur Frage der Scharlachdiphtherie Centrabl. f. Bakt and Parasit., X. Band, No. 1) examined bacteriologically seven cases of "typical scarlatinal diphtheritis,"—that is to say, cases in which pseudo-membranous inflammation of the fauces occurred during the first week of the scarlatina,—without discovering in any of them bacillus diphtheriæ. These cases, he notes, all recovered without any appearance of croup of the larynx or trachea, and without any subsequent paralysis. He too arrives at the conclusion that the so-called scarlatinal diphtheritis, *i.e.*, that concurrent with (not subsequent to) scarlatina, is not true diphtheria.

So that there is a remarkable consensus of opinion that the conclusion arrived at previously by Hensch and Heubner from a clinical point of view, viz., that scarlatinal diphtheritis is distinct from true diphtheria, is the correct one. While on the other hand, in regard to cases of croup of the larynx and trachea (not derived from, or associated with, cases of true diphtheria of the fauces), the bacteriological researches of Löffler, Kolisko and Paltauf do show certain of these cases to be true diphtheria, since the bacillus diphtheriæ was demonstrated in the membrane; and this notwithstanding that in some of them the anatomical characters were not such as are regarded by pathologists as characteristic of diphtheria.

Scarlatinal diphtheritis *not* diphtheria.

Further Investigations.

In the course of the last two years I myself have had opportunity of examining eight cases, which differed inter se as did those described by Löffler and by Kolisko and Paltauf. These cases will now be dealt with in reference to the result of the bacteriological examination to which they were subjected.

Case 1.—J. C., aged three years and a half, had on admission to hospital typical diphtheritic membranes on the tonsils and pharynx, with symptoms also of croup. The child died on the third day after admission, two days after tracheotomy had been performed. On *post-mortem* examination the tonsils, the whole of the pharynx, larynx, and the upper third of the trachea were found covered with typical diphtheritic membrane. In the upper part of the trachea the membrane became very thin, from above downwards, and gradually disappeared. There was also broncho-pneumonia. Cover-glass specimens made of scrapings from the surface of the tonsils, pharynx, larynx, and trachea, revealed in each instance crowds of the diphtheria bacilli. And in sections through the larynx and upper part of the trachea, these bacilli were observed to form in the superficial parts of the membrane continuous masses and large clumps, and to extend in lines and in nests somewhat into its deeper layers; a condition exactly similar to that illustrated in figures 15 and 16 in the Report of the Medical Officer for 1889. Particles of the diphtheritic membrane taken from the larynx or trachea and transferred (after washing well in two or three successive lots of sterile salt solution) to different culture media, yielded the diphtheria bacillus in pure culture. And subcutaneous inoculation of guinea-pigs proved these cultures to be virulent.

"Croup" found to be diphtheria.

Case 2.—F. O., aged 5 years and 5 months, had on admission to hospital,* dyspnœa and croup of the larynx. The mucuous membrane of the throat appeared injected, but there was no membrane. Tracheotomy was performed, but the child died four days afterwards. On *post-mortem* examination, the larynx and almost the whole of the trachea showed distinct diphtheritic membrane. In addition the lower part of the pharynx behind the larynx was covered with diphtheritic membrane which thinned off towards the upper part of the pharynx. Pneumonia also was present. Microscopic examination of the laryngeal and tracheal membrane, in cover-glass specimens and in sections, as also by culture, proved the presence of large numbers of the diphtheria bacillus; in fact in sections through the larynx they formed, in the superficial parts of the membrane, almost unbroken layers, while extending also as considerable masses in many places into the deeper parts. The sections in question, stained first in rubin and then in methylblue, showed the

* I am indebted to Dr. Woodhouse, Assistant Medical Officer at Fulham Fever Hospital, for this case and also for cases 3, 4, 5, and 7.

bacillary masses stained deep blue in a red ground; and presented indeed a remarkable instance of rich abundance of masses of diphtheria bacilli: such an one I have not met with before or since.

Scarlatinal diphtheritis *not* diphtheria.

Case 3.—A. R., aged 9 years, died from scarlatina and diphtheria on the eighth day of her illness. No post-mortem was allowed, but a portion of the tonsils (ulcerated and covered with grey-yellow débris) was obtained. This material was used for cover-glass specimens, for sections, and for cultures. In the cover-glass specimens were observed numerous cocci (some in chains) and slender long bacilli; but no diphtheria bacilli could be found. On section the mucous membrane was found to be densely infiltrated, the superficial part of it completely disorganised and transformed into a débris in which whole nuclei, as well as remnants of nuclei, could be still distinguished. This part of the mucous membrane contained continuous masses of cocci. But cultures from the membrane yielded no diphtheria bacilli.

Diphtheria following scarlatina, true diphtheria.

Case 4.—G. C., aged 6 years, was admitted to hospital, March 29th, with scarlet fever; a well-marked case. Rash bright and general; throat dark red; tonsils enlarged and superficially ulcerated. On April 10th, the throat having in the meantime become quite clean, there occurred, along with rise of temperature to 100° F., swelling of the right parotid gland. This swelling subsided in 48 hours, but there was, on April 13th, swelling of the left parotid. On April 16th croupy cough set in; the tonsils now looked inflamed, and there appeared something like membrane upon both. April 17th tracheotomy was performed, and much membrane was found in the trachea. No post-mortem was allowed; but a piece of membrane was obtained from the trachea, and this was used for cover-glass specimens and for culture. Cover-glass specimens, made from pieces of the membrane that had been first well washed in sterile salt solution, showed a fair number of organisms, namely, diplococci, and bacilli which looked like the diphtheria bacillus. Lymph corpuscles were also observed which contained these micro-organisms within their substance; in some cases two or three, in others over a dozen. Sections made through this membrane showed the characteristic reticulated necrosed matrix; in its superficial parts were numerous leucocytes, deeper down were numerous blood corpuscles in masses or generally diffused. The micro-organisms referred to were not, however, by any means numerous in the sections; in this respect they differed somewhat strikingly from sections made from cases 1 and 2 of this series. Three cultivations, made by rubbing a piece of membrane (previously washed in three successive lots of sterile salt solution) over the slanting surface of nutrient gelatine, showed in each tube, after about a week's incubation, two kinds of colonies:—(*a*), large colonies, round and whitish; and (*b*), small whitish colonies, with thick centres and thin margins. The first proved to be a beautiful streptococcus, the second undoubtedly the diphtheria bacillus. The relative proportions in the several tubes of the two kinds of colonies were as follows:—

Tube 1 contained	13	colonies of	the streptococcus, and over 150 colonies of the bacillus diphtheriæ.
Tube 2	„	9	„	streptococcus, and 112 of the bacillus diphtheriæ.
Tube 3	„	5	„	streptococcus, and 120 of the bacillus diphtheriæ.

In each of these tubes there was present a third species, namely, a minute coccus forming small spherica brown colonies. The number of

these, however, was insignificant; in one tube a single colony, in the second three, and in the third two colonies. So that the bacillus diphtheriæ * was present in greatly preponderating numbers. Inoculations of guinea-pigs with broth culture of this bacillus gave positive results; the cultures proved all virulent.

"Croup," true diphtheria.

Case 5.—L. W., aged 4 years, admitted to hospital April 20th. Had had sore throat and croupy cough for a week previous to admission. On admission, throat inflamed; no membrane on tonsils or fauces; marked dyspnœa and hoarse cough. Tracheotomy performed on the day of admission; several pieces of membrane taken from trachea and larynx at the operation. Died April 22nd. On *post-mortem* examination there was found membrane throughout the larynx and trachea, extending even into the smaller bronchi. This membrane was especially thick in the larynx. The lungs were almost collapsed. Cover-glass specimens of the membrane from the larynx (after washing a particle of it in sterile salt solution), and cultivations therefrom, showed the diphtheria bacillus present in large numbers. Besides the diphtheria bacillus there was staphylococcus albus liquescens, and a non-liquefying bacillus forming yellow colonies. But the latter two microbes were present in the cultures only in very small numbers.

"Croup," true diphtheria.

Case 6.—A. T., aged 3, ill since May 20; croupy since May 21. Had on admission to hospital, 22nd May, a membranous patch on one tonsil, but none in the pharynx. Tracheotomy was performed on the morning of May 23rd; but the child died at 4 a.m. on the next day. *Post-mortem*:—Diphtheritic membrane was found in the larynx and upper part of the trachea; in the lower part of the trachea purulent membrane extended into the bronchi. Both tonsils were slightly enlarged, and on the left tonsil were two small grey patches. The pharynx was injected, but without membrane. Pieces of membrane coughed up on May 23rd were examined in cover-glass specimens and by culture. The diphtheria bacillus was found present in large numbers; as also in the membrane taken from the larynx after death, wherein the diphtheria bacilli could be easily demonstrated by cover-glass specimens, and by culture.

Post scarlatinal diphtheria, true diphtheria.

Case 7.—H. H., aged 4, was admitted to hospital on May 18th with well-marked scarlet fever; a mild case. On May 31st there was some secretion on the tonsils; also otorrhœa on the left side. On June 16th both tonsils were found inflamed, enlarged, and covered with a membrane-like secretion; temperature in the evening of this day 101° F., pulse 100; vomited several times. On June 17th membrane on tonsils was distinct. On June 18th breathing hurried; enlarged glands at both angles of the lower jaw. Tracheotomy was performed at midnight, and a cast of the tube was coughed up. On June 19th, the child going on well; no more membrane coughed up, and ultimately there was recovery. A piece of the membrane removed on June 18th after tracheotomy, was, after having been well washed in sterile salt solution, examined in cover-glass specimens, and by culture. In the cover-glass specimens

* It ought, however, to be stated that although in morphological respects and in action on the guinea-pigs this bacillus appeared to be the diphtheria bacillus, it nevertheless at first showed culturally some differences. It at first grew slower both on agar and on gelatine, and its colonies were smaller than those of the typical diphtheria bacillus out of the membrane of the fauces obtained from cases of typical diphtheria. The aspect and general character of the colonies was, however, the same, and after two or three generations it showed the same rapidity of growth as the typical diphtheria bacillus.

there were found small and isolated groups of the diphtheria bacillus; only here and there, in addition, a diplococcus. Of six culture tubes (slanting agar) inoculated with a piece of the membrane, five showed each several colonies of the diphtheria bacillus; the sixth tube showed in addition one colony of staphylococcus. Experiments on two guinea-pigs, by subcutaneous inoculation with these cultures, proved them to be the true diphtheria bacillus.

"Croup," not true diphtheria.

Case 8.—M. T., aged 5, an in-patient of the hospital for "simple catarrhal laryngitis," was discharged on January 31st, much improved. On February 5th this child was re-admitted, with much dyspnœa, laryngeal croupy cough, and lividity of face. Tracheotomy was performed February 6th. On that day, and on February 7th and 8th, much membrane was coughed up. The patient recovered. Neither in cover-glass specimens, nor in sections, nor by culture could the diphtheria bacillus be demonstrated in the membrane that had been coughed up.

Summary.

These observation of mine, then, which are fully in harmony with those of other writers, are to the following effect:—

(1.) Membranous croup of the larynx and trachea occurring concurrently with diphtheria of the fauces, is *true* diphtheria;

(2.) The so-called scarlatinal diphtheria is not true diphtheria;

(3.) Diphtheria of the fauces, as also membranous croup, following some time after scarlatina, are both true diphtheria;

(4.) Membranous croup of the larynx and trachea without diphtheria of the fauces, may be of two kinds:—(*a*), true diphtheria (case 5); or (*b*), genuine fibrinous croup without presence of the diphtheria bacillus, and therefore not (from this point of view) true diphtheria (case 8).

As to the fact that fibrinous, membranous, non-infectious exudation on the surface of the mucous membrane can be experimentally produced (as, for instance, by a chemical irritant), there is no doubt. It is well established by numerous observations, as for instance of Bretonneau, Delafond, Reitz, and others. There is therefore no theoretical reason to deny the possibility of a fibrinous inflammation of the larynx,—*i.e.*, a form of membranous croup,—occurring in children altogether independently of the diphtheria bacillus, and distinct therefore from diphtheria.

II.—*Further Observations on Bacillus Diphtheriæ.*

Attenuation of bacillus diphtheriæ by culture.

In my report for 1889 I pointed out that the action of cultures of the diphtheria bacillus on animals (guinea-pigs) differed considerably with the different culture media employed, and varied also with the age of the culture. Thus it was found (p. 155) that recent cultures of the diphtheria bacillus in alkaline broth,—*i.e.*, a few to several days old,—were the most virulent; and that recent cultures on agar, though also virulent, became later on (incubated eight days or more at 37° C.) considerably less potent. Similarly gelatine cultures were, after several weeks' incubation, found, on inoculation into guinea-pigs, to act less virulently than they had done when recently established.

Brieger and C. Fraenkel (Berliner Klin. Wochenschrift, N. 49), produced attenuation in virulence of the diphtheria bacillus by cultivating it at higher temperatures, or by adding to the culture medium potassic bichromate or gentian violet. The attenuation of such cultures was proved in the usual way, viz., by the protracted illness, and the more or less delayed death, witnessed in experimental animals inoculated therewith.

But these observers found the attenuation thus produced quite unreliable, since occasionally the cultures were suddenly found again virulent. As regards attenuation, therefore, that constantly observed to occur in cultures on agar after incubation for a week or more at 37° C. is preferable, because more to be relied on.

During 1891 I have attempted to find culture media à priori not very favourable to the growth and multiplication of the diphtheria bacillus, and to be thought of therefore as perhaps capable of producing a definite attenuation of its virulence. And in this sense I have tested in some detail acid-broth, and grape-sugar-gelatine.

Use of acid-broth for this purpose.

Most pathogenic bacteria require for their satisfactory and normal growth a faintly alkaline or at least a neutral broth. Consequently I was not a little surprised to find that the diphtheria bacillus grows well and possesses full virulence in broth of which the reaction is so *decidedly acid* that violet litmus is turned red by it in a pronounced way. Acid-broth of this description inoculated with the diphtheria bacillus and incubated at 37° C., becomes slightly turbid as early as after 24 hours. After two or more days' incubation there is in it a whitish powdery precipitate not very voluminous, and there are always whitish granules along the wall of the test tube at the surface of the broth. In such an acid-broth culture, the growth of diphtheria bacillus, though it is distinctly less copious than in broth faintly alkaline, is nevertheless tolerably vigorous and must be pronounced a fair growth. And further, if subcultures from this acid-broth diphtheria culture be made also in acid-broth by several successive removes,—that is, if from a first acid-broth culture a second acid-broth culture be established, and from this a third acid-broth culture, and so on,—no change in the character or amount of the bacillus growth is noticeable. In the experiments in question, for the purpose of securing uniformity, the same stock of acid-broth was used in all subcultures, and the time during which each subculture was incubated at 37° C. was always the same, *i.e.*, 48 hours. Under these conditions there was no alteration whatever in the typical morphological appearances of the diphtheria bacillus however far removed the subculture from the original source. Indeed I have examined the diphtheria bacillus thus dealt with up to the twentieth subculture, and neither in its fresh state nor as a dried and stained cover-glass specimen did I find microscopically any change at all. Nor, strange to say, was the slightest alteration in virulence of this bacillus produced by repeated subculture in the above fashion. This I have tested by a considerable number of inoculations of guinea-pigs, using for their subcutaneous injection the same quantity of acid-broth subculture in each experiment, and using always acid-broth subculture of exactly the same age, *i.e.*, 48 hours. Thus, immediately after inoculating from a given subculture a further subculture, a definite quantity of the former was also employed for the subcutaneous inoculation of a guinea-pig. In this way I have tested acid-broth subcultures of bacillus diphtheriæ up to the twentieth remove, and in every instance the experimental animal died from the acute disease;—*i.e.*, within two or three days of inoculation, and with the symptoms described in my report for 1889. Another noteworthy feature of these experiments is the circumstance that the original acid reaction of the broth subcultures remained unaltered during the growth of the diphtheria bacillus, in the several tubes that were tested after 10 days to a fortnight's incubation at 37° C. Further, transference from each of the acid-broth subcultures—1st to 20th remove—of material on to normal (alkaline) nutrient agar, and on to normal nutrient gelatine,

Result negative.

resulted always in typical growth on these non-acid media of the diphtheria bacillus.

In all the above respects, therefore, the diphtheria bacillus would seem to be possessed of striking peculiarities. Many other pathogenic bacteria show little or no growth in acid-broth; on the contrary after prolonged incubation in such broth they (unless in spore form) commonly lose their vitality.

Grape-sugar-gelatine as a medium.

In cultures of the diphtheria bacillus in grape-sugar-gelatine, this microbe was found quite normal, both morphologically under the microscope and pathologically in its action on guinea-pigs. But its growth on grape-sugar-gelatine proceeded a little slower than on ordinary nutrient gelatine, and the vitality of the culture ceased considerably earlier than is the case in culture on the latter medium. Thus, whereas cultures on nutrient-broth-gelatine (broth, gelatine, peptone, and salt) when tested after 20 months still showed vitality (*i.e.*, good and active subcultures could be started from them), the grape-sugar-gelatine cultures of the bacillus were found dead after four months.

Also negative.

No. 2.

Further Observations on Concurrent Inoculation of Different Infections in the same Animal Body; by Dr. Klein, F.R.S.

In last year's (1890) Report, I gave an account (p. 243) of experimental inoculation into the same animal body of two different pathogenic microbes. As a result, it was ascertained that the bacillus diphtheriæ and the bacillus anthracis do not exhibit antagonistic action within the same animal. And further it was ascertained that injection of culture of bacillus pyocyaneus, whether containing the living organism or whether sterilised by heat, had no effect in restraining the action of bacillus diphtheriæ antecedently or subsequently inoculated into a given animal; that, indeed, on the contrary, bacillus pyocyaneus and its products tended rather to enhance the pathogenicity of bacillus diphtheriæ.

Experiments of similar sort have been continued during 1891, as follows:—

A.—Erysipelas and Vaccinia.

The inter-relations of erysipelas and vaccinia are for obvious reason matter of much interest, and it becomes, therefore, the more necessary to ascertain experimentally how the two viruses behave when introduced simultaneously into the calf.

Sources of erysipelatous material.

Fehleisen long since established the fact that, alike with erysipelatous material and with pure culture of the streptococcus erysipelatos, true erysipelas can be produced in the ear of the rabbit; and accordingly rabbits were chosen by me for the purpose of establishing a stock of erysipelatous infection. In order to show in detail the nature of the material which was used for the inoculation of my experimental calves, details are here given of the course of procedure as regards two series of preliminary experiments with rabbits.

Preliminary procedures.

Series I.—*Inoculation of the Rabbit with the Raw Material of Erysipelas.*—From an erysipelatous ear of a rabbit, red, swollen, and œdematous after inoculation therein of a gelatine culture of the streptococcus erysipelatos, serum was obtained by incision into the subcutaneous tissue. This serum was now injected into a small incision into the skin about the root of the ear of another and healthy rabbit. Next day the region of the inoculation in rabbit No. 2 was red and slightly tumid, and in the course of other few days this redness and swelling increased and spread. By the sixth day this rabbit's ear was pendant; from the root to the tip it was intensely swollen, felt puffy, and was œdematous. The greater part of it, moreover, was deeply injected, and felt hot to the hand. On incision, followed by pressure, of the skin, large quantities of clear serum flowed from the ear. From this serum the streptococcus erysipelatos was easily obtained in numerous colonies by culture on gelatine and on agar. Forty-eight hours later, serum obtained from the ear of this rabbit No. 2 was injected into the skin of the ear of a third rabbit. On the fifth day the condition of the ear of rabbit No. 3 was typical; the ear was pendant, swollen and puffy, red, and hot. On incision, followed by pressure, of the swollen part, serum was easily obtained in considerable quantity. On the eighth day serum taken from the swollen œdematous ear of this rabbit (No. 3) was injected into the ear of rabbit No. 4. In this case, also, typical erysipelas of the inoculated ear was the result; on the sixth day the whole ear was swollen, red, œdematous, and hot.

In all three experimental rabbits (Nos. 2, 3, and 4) the erysipelatous condition of the ear advanced for more than a week. By the tenth or eleventh day the redness had for the most part gone; but in more than one rabbit blisters were now noticed on the surface of the swollen ear. These blisters being opened, clear serum freely oozed out and dried up. Elsewhere on the ear the cuticle was desquamating in large flakes.

Series II.—*Inoculation of the Rabbit with Culture of Streptococcus Erysipelatos.*—In this series erysipelas was successfully started in the rabbit's ear with gelatine culture of the streptococcus erysipelatos, derived on the third day after its inoculation from the serum of the swollen ear of the rabbit No. 2, Series I. Here again, the result was typical erysipelas; on the fourth, fifth, and sixth days the whole ear was red, swollen, œdematous, hot, and pendant. Sections made through the swollen and œdematous ear (the animal having been killed on the sixth day), showed the streptococcus erysipelatos in large and small masses in the lymph spaces, and in the lymph vessels of the œdematous skin. These masses were especially numerous on the outer surface (the surface inoculated), where some of the lymph vessels were filled with the streptococci filaments twisted, convoluted, and matted together.

Having thus obtained good and active erysipelas material, I tested on *calves* the serum squeezed out of the œdematous ear, as well as pure cultures therefrom of the streptococcus erysipelatos.

Experiment I.

Inoculation of calves:

A calf (No. 1) was inoculated, in over 20 cutaneous incisions and punctures of the skin of the groin and abdomen, with *serum* freshly squeezed out of the erysipelatous ear of rabbit No. 3; the disease in this latter animal being then in the fifth day.

with erysipelatous serum;

All incisions and punctures in calf No. 1 had by the fourth day entirely faded away. There was no redness, and no swelling.

with erysipelas culture.

The same calf was therefore on the fifth day again inoculated, this time in the subcutaneous tissue of the groin, with *broth culture* of the streptococcus erysipelatos (48 hours old); which culture was proved virulent by inoculation into the ear of a control rabbit. This further inoculation of calf No. 1 had, however, no result at all.

Experiment II.

The above experiment was repeated on a second calf (No. 2), with serum squeezed, on the sixth day, out of the erysipelatous ear of the rabbit No. 4, and with a *gelatine culture* of the streptococcus from the serum that had proved virulent on the rabbit's ear. In this calf, also, the result was negative.

Experiment III.

With vaccinia;

Calf (No. 3) was vaccinated, in 20 incisions, with calf lymph (96 hours) obtained from the Government Animal Vaccine Station. This calf developed in all incisions typical vaccinia. These were scraped on the sixth day, and the scraped surface of ten of the incisions was inoculated

and afterwards with eyrsipelas.

with fresh serum squeezed (on the fifth day after its inoculation) out of the erysipelatous ear of a rabbit; the other ten incisions being left untouched for control. No difference was noticed on subsequent days between the incisions that were left untouched and those that had been inoculated with the erysipelas serum. All followed the same normal course of vaccinia; the areola, the size and thickness of the subsequent scab, the time of the loosening of the scab, and the healing of the incisions were in both sets similar.

Experiment IV.

Calf No. 4 was vaccinated, in 20 incisions, with the scrapings taken on the sixth day from the vaccinia incisions of the calf (No. 3) of Experiment III. At the same time active *broth culture* of streptococcus erysipelatos was dropped upon these 20 incisions and well rubbed into them. The result was, as regards erysipelas, negative. But all 20 incisions developed typical vaccinia. On the sixth day these 20 incisions were scraped as in calf No. 3, and 10 of them were then inoculated with active *broth culture* of the streptococcus erysipelatos; the other 10 being left for control. But no difference in the nature and progress of the 20 incisions could at any time be detected.

Concurrently with vaccinia and with erysipelas.

From these experiments it would appear that calves are altogether insusceptible to erysipelas. The material of this disease when inoculated into them primarily and separately, produced no effect at all. And similarly, whether inoculated along with vaccinia, or inoculated after vaccinia had been fully established, it completely failed to modify in any way the course of the vaccinia that was in each instance induced.

Summary of results.

B.—The Aerobic Bacillus of Malignant Œdema and the Bacillus of Grouse Disease.

These two microbes belong to the same group of organisms; indeed in their morphological and cultural characters they are extremely difficult to distinguish one from the other. Nevertheless, in respect of their physiological action on animals, they appear quite separate and distinct.* Both are aerobic bacilli, exhibiting short mobile rods. They both grow well on gelatine without liquefying it, and in plate cultivation they form the same kind of colony. In both these respects they resemble the bacillus of the Middlesbrough pneumonia, described and illustrated by me in the Report of the Medical Officer for 1888. Injected separately and in small doses into *mice*, the aerobic œdema bacillus and the bacillus of grouse disease alike produce septicæmia and death of these animals in from one to three days; the blood of the general circulation and the viscera being found after death to contain the bacilli in abundance. On *guinea-pigs* their action, too, is much alike, though the grouse bacillus produces physiological effect on these animals in smaller doses than does the œdema bacillus. Nevertheless the œdema bacillus when injected in considerable quantity produces death of the guinea-pig in a larger per-centage of cases than the grouse bacillus. Further, the œdema bacillus produces in the guinea-pig a distinct and spreading œdema about the seat of inoculation. As regards *rabbits*, the œdema bacillus is virulent to rabbits, while the grouse bacillus is inactive on these animals. There can be no doubt therefore that the two organisms are, as I have said, separate and distinct the one from the other.

Broth cultures made of these two bacilli, having, after 48 hours' incubation at 37° C., become in each instance uniformly turbid, owing to the copious multiplication of the microbes, were used for the inoculation of white mice. Definite quantities, 5 minims in each case, were injected under the skin of the back of the animal: a dose which generally suffices with mice to produce distinct general illness followed in most cases by death.

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* In the Centralblatt f. Bacteriologia und Parasitenkunde, and in "Grouse Disease and Fowl Enteritis" now (1892) being published by Macmillan, I have described these organisms in detail.

Experiment 1.

(*a*.) Two mice were inoculated with broth culture of the aerobic œdema bacillus;

(*b*.) Other two mice were inoculated with broth culture of the grouse bacillus; and

(*c*.) Additional two mice were at the same time inoculated with a mixture of equal parts ($2\frac{1}{2}$ minims of each) of the two broth cultures.

Mice inoculated with: Œdema bacillus; grouse bacillus; both organisms.

After 24 hours:—

One of the two (*a*) mice was found dead, the other being very quiet and ill.

The two (*b*) mice were very quiet and ill.

The two (*c*) mice were not appreciably affected.

After 48 hours:—

The second (*a*) mouse was still very quiet and ill.

Both (*b*) mice were found dead.

Both (*c*) mice were seemingly still all right.

From the three dead mice (one of (*a*) and two of (*b*))—as indeed from all mice which died in this series of experiments—cultivations were made of the heart's blood, and the microbe that had in each instance been used for inoculation was thus recovered therefrom in abundance. The second mouse (*a*) gradually recovered, and was all right again and lively on the 12th day.

Experiment 2

Consisted of repetition of experiment 1.

After 48 hours:—

One (*b*) mouse was found dead, and the other appeared very ill.

The two (*a*) mice were seemingly all right.

The two (*c*) mice were quiet and off their food.

After four days:—

Both (*a*) mice and one (*c*) mouse were found dead.

The other (*b*) mouse, and the other (*c*) mouse were seemingly all right.

Experiment 3

Was repetition of experiments 1 and 2.

After 48 hours:—

Both (*a*) mice and both (*b*) mice were found dead.

Both mice (*c*) seemed all right, and they remained well afterwards.

Summary of results.

From these experiments it is seen that the simultaneous inoculation of mice with broth culture of the œdema bacillus and with broth culture of the grouse bacillus, has a strikingly different result from that which follows when either broth culture is injected into separate animals. Of the six mice inoculated with the œdema bacillus *alone*, five succumbed, and but one recovered. Similarly of the six mice inoculated with the grouse bacillus *alone*, five succumbed, and but one recovered. Whereas of the six mice simultaneously inoculated with the œdema bacillus and the grouse bacillus, one only succumbed, while the other five survived.

Now, if these two microbes had no antagonistic action within the animal body, the mice inoculated with both bacilli mixed together ought to have succumbed; for two minims of a broth culture of either bacillus 48 hours old,—such as was used in the above experiments,—fully suffice to produce disease and death in these animals,—as has been proved by a large number of experiments previously made by me. Still more, therefore, was a fatal result to be looked for when no less than five minims of the mixed broth cultures were used for each mouse. But

we find as a matter of fact that five out of six animals inoculated with five minims of the mixed cultures survived, whereas five animals out of six died when inoculated with equal quantity of either of the two microbe cultures separately. Accordingly, it is obvious that the two microbes introduced simultaneously in equal quantities contrived somehow or other to neutralise one another's action; and that, therefore, they are within the animal body antagonistic the one to the other.

Since the bacillus of the grouse disease, in morphological and cultural respects, belongs to the same group of microbes as the bacillus of the Middlesbrough pneumonia,* it now became interesting to ascertain whether this latter bacillus and the bacillus of grouse disease were mutually antagonistic in the mouse after the same fashion as the bacillus of grouse disease and the aerobic bacillus of malignant œdema.

Mice inoculated with:

Experiment 4.

(*a*.) Two mice were inoculated with broth culture (48 hours old) of the pneumonia bacillus.

pneumonia bacillus;

(*b*.) Two mice were inoculated at the same time with a mixture of equal parts of the broth culture of the pneumonia bacillus and of broth culture of the grouse bacillus.

pneumonia bacillus plus grouse bacillus.

After 24 hours:—One (*a*) mouse and one (*b*) mouse were found to be dying, and their companions were ill and quiet. These two, however, one (*a*) mouse and one (*b*) mouse, recovered.

Experiment 5.

(*a*.) Two mice were inoculated with broth culture of the grouse bacillus.

(*b*.) Two mice were at the same time inoculated with a mixture of the pneumonia and grouse bacillus cultures.

After 48 hours all four mice were found dead.

It follows then, from these experiments, that these two bacilli, viz., the grouse bacillus and the pneumonia bacillus, do not possess any antagonistic action.

C.—The Bacillus of Mouse Septicæmia (Koch) and the Bacillus of Swine Erysipelas.

Pigeons inoculated with:

These two microbes, as is well known, belong to the same group. As regards morphology and cultural characters in gelatine and agar, they differ very little. But though their action on mice is similar, they do differ as regards their action on pigeons. Thus the bacillus of swine erysipelas is pathogenic for the pigeon; it produces death in about 3–5 days, and the bacilli are found abundantly in the blood of the general circulation and of the viscera. The bacillus of mouse septicæmia however has no action on pigeons.

Experiment 6.

(*a*.) A pigeon was inoculated with broth culture (incubated 48 hours at 37° C.) of the bacillus of mouse septicæmia;

mouse septicæmia;

(*b*.) A second pigeon was inoculated with broth culture (48 hours old) of the bacillus of swine erysipelas; and

swine erysipelas;

* The bacillus of the Middlesbrough pneumonia can be readily distinguished from the microbes just dealt with, by growing all three in broth or on potato. Bacillus pneumoniæ (Middlesbrough) grows decidedly more copiously in these media than either œdema bacillus or the grouse bacillus.

both organisms.

(*c*.) Other two pigeons were inoculated with a mixture of the two broth cultures.

On the fifth to the sixth day, the (*b*) pigeon and both (*c*) pigeons were found dead. The (*a*) pigeon was, however, well, and remained so.

Cultivations were made of the heart's blood of these three animals, and the bacillus of swine erysipelas was recovered from all in numerous colonies.

Experiment 7

Was repetition of Experiment 6, and with exactly the same result.

Summary of results.

It follows, then, from this, that, within the pigeon, the bacillus of mouse septicæmia (which is non-pathogenic to this bird) exerts no antagonistic action on the swine erysipelas bacillus. As a result of their simultaneous inoculation the former is killed, while the latter goes on to produce its pathogenic action in its customary manner.

Other experiments.

Several additional experiments were made on *rabbits* by inoculating them simultaneously with culture of the bacillus of *fowl cholera* to which rabbits are highly susceptible, and with culture of the bacillus of *fowl enteritis*,* to which rabbits are susceptible only very slightly indeed. The result was nil, inasmuch as all the animals inoculated with the mixture died of fowl cholera in the usual time.

These two microbes were also used for simultaneous inoculation of *fowls* and *pigeons*. The fowl is susceptible to both microbes; the pigeon, however, while susceptible to fowl cholera, is insusceptible to the fowl enteritis.

In these experiments also the result was negative ; for the fowls and the pigeons inoculated with the mixture died alike of fowl cholera.

With reference to these experiments, however, it deserves to be mentioned that fowl cholera is considerably more acute than fowl enteritis. Fowls inoculated with active culture of the bacillus of fowl cholera are generally found dead in one to two days, whereas fowls inoculated with active culture of the bacillus of fowl enteritis do not develop their first symptoms of disease before the fourth or fifth day. So rapid indeed is the action of the bacillus of fowl cholera that great difficulty was met in conducting the above experiment in a satisfactory manner; there being the risk that the bacillus of fowl enteritis, even if it possessed any antagonistic action, might, if inoculated simultaneously with bacillus of fowl cholera, not find time for exerting it in the body of the experimental animal. As to this, however, I have ascertained, by direct experiment, the following two facts :—

(1.) Fowls which have been affected with fowl enteritis, but which have recovered, remain susceptible to infection with fowl cholera.

(2.) Pigeons inoculated with large doses of active culture of the bacillus of fowl enteritis, when subsequently—a few days later—inoculated with the culture of the bacillus of fowl cholera, succumb to fowl cholera in the usual time and with the typical symptoms of fowl cholera.

* Described by me in the Centralb. f. Bact. und Parasit., Vol. V., 1889, and in " Grouse Disease and Fowl Enteritis," Macmillan, 1892.

No. 3.

Report on the Action of the Bacillus Pyocyaneus on the Process of Tuberculosis; by E. Klein, M.D., F.R.S.

I.—Experiments on Guinea-pigs.

As long ago as the winter of 1889–90 I was experimenting with a view to ascertaining how far tuberculosis artificially induced in guinea-pigs by inoculation of tubercular matter from human or bovine sources could, after it had been established several weeks—as shown by the typical swollen, caseating, and suppurating lymph-glands at the site of inoculation—be retarded or controlled by repeated injection in small quantity into such guinea-pigs of *sterilised* cultures of tubercle bacillus.

The tubercle cultures that I employed were broth albumen cultures, made by adding to a test tube of ordinary faintly alkaline beef broth peptone a piece of boiled white of egg, and then inoculating this medium with a particle of material from a living glycerine agar-culture of the tubercle bacillus. In such a tube, properly capped and incubated at 37° C., there appears, generally after five or six days, the first indications of successful inoculation; the broth, previously quite limpid, begins to show small granules at the bottom. During subsequent incubation these increase in number and become larger, constituting whitish-grey flakes. After a fortnight to three weeks or more, a considerable amount of whitish, granular, floccular, and stringy growth is deposited on the egg albumen; and at the same time there is noticeable a trace of a thin, scaly, whitish film on the surface of the broth. As incubation proceeds, and the amount of the growth on the egg albumen increases, the white pellicle becomes more pronounced. By shaking the tube, the pellicle soon breaks up into small particles, most of which fall to the bottom of the fluid. When tested by the customary methods of staining, the growth at the bottom of the tube and the pellicle at the surface of the fluid are shown to be typical tubercle bacilli.*

Tuberculous guinea-pigs injected with products of the tubercle bacillus:

The above cultures when six to eight weeks old contained copious masses of tubercle bacilli, and before use for experimental purposes were sterilised by boiling. Material from them, mixed with sterile salt solution, was then injected into guinea-pigs that had been three to four weeks previously inoculated with tubercle. The injection was always made into the subcutaneous tissue of the left side of the abdomen, the right groin, previously inoculated with tubercular matter, having by this time become the seat of swollen, caseous, and suppurating lymph-glands.

In my earlier experiments the sterilised material thus injected consisted of one part of broth culture in 100 parts of sterile salt solution, six divisions of a Pravaz syringe of this mixture being used for each guinea-pig. In later experiments the strength of the material used was greatly increased, up to three, sometimes to five, Pravaz syringe divisions of the culture *undiluted*. And even with the latter quantity, the immediate physiological result was only a rise of temperature,

* Cultures of the above sort were exhibited by me at a meeting of the Physiological Society in December 1889 while these experiments were in progress: nearly a year therefore antecedent to announcement by Koch of "Tuberculin" as a material inhibitory of Tuberculosis.

after about two hours, amounting to from four to eight tenths of a degree Centigrade; the temperature falling again to normal after about seven hours.

On the day following the first injection of sterilised culture, the dose was repeated; and thenceforward the animals were re-inoculated day by day for some considerable time. Within a week or so there was a firm circumscribed swelling at the site of the injection, and in a few instances the lymph-glands of this locality became enlarged and firm.

result negative.

The result of these injections on the primary tubercular process was, however, disappointing, for comparing the experimental guinea-pigs with the control guinea-pigs, no distinct modification of the progress or intensity of the tubercular process could be discerned. In illustration, I cite one of several such series of experiments, namely, a series in which at first the diluted, and later the undiluted, sterilised culture was injected into tubercular guinea-pigs.

Six guinea-pigs, inoculated on October 29th, 1889, in the right inguinal region with *human* tubercle, all exhibited after three weeks enlarged glands in the inguinal region thus inoculated; in some these glands were by now already suppurating. At this time (November 19th) each of these guinea-pigs received, in the left inguinal subcutaneous tissue, six divisions of a Pravaz syringe of a sterilised broth culture of tubercle, diluted 1 in 100. This injection was repeated on November 20th, 21st, 22nd, 24th, 25th, and 28th, and on December 1st, 2nd, 3rd, 4th, 5th, 6th, 8th, and 9th. On December 10th the previous dose was doubled, and this increased dose was likewise injected on December 11th. On December 12th the dose was further increased to 20 divisions of the Pravaz syringe, and the same quantity was injected on December 13th, 15th, 16th, 17th, 18th, 19th, 20th, 22nd, 23rd, 24th, 27th, and 30th. On January 6th, 1890, each of the six guinea-pigs had one or more large suppurating open abscesses at the seat of the primary tubercle inoculation. One of them killed at this date showed tubercle deposits in the liver and in the enlarged spleen, and both lungs were distinctly hyperæmic. The remaining guinea-pigs were the same day further injected, each receiving three Pravaz divisions of the *undiluted* sterile broth culture; an injection which was repeated on January 7th, 8th, 9th, 12th, and 13th. On January 14th one was found dead; and presented, *post-mortem*, large caseous inguinal glands; liver enlarged and mottled with tubercle; grey and yellow tubercles in both lungs; spleen enlarged, and granular with minute tubercles. All the other four guinea-pigs were now killed, and were found to present distinct tubercles in the spleen, liver, and lungs; also enlarged suppurating open glands in their right groins.

As regards this series of experiments, it appears then that the result was negative. Injection of the sterilised culture of the tubercle bacillus into tuberculised guinea-pigs was not productive of any inhibition of the normal progress of the tubercular process. The condition of visceral tuberculosis found in them was indeed such as is commonly found after a like lapse of time in the ordinary guinea-pig when inoculated with human tubercle.

So too in a second series, guinea-pigs that had been previously inoculated with *bovine* tubercle were subjected to the same kind of injection with sterilised cultures of the tubercle bacillus. In this series the result was also negative.

Tuberculous guinea-pigs injected with products of pacillus pyocyaneus:

I next proceeded to inject into guinea-pigs that had been previously inoculated with tubercle and sterilised broth culture of bacillus pyocyaneus.

As to bacillus pyocyaneus, some preliminary experiments therewith are referred to in my paper of last year, page 246 of the Report of the Medical Officer for 1890. In the same volume (pp. 244–45) the peculiar gelatinous character of broth cultures of this micro-organism are described, as also the fact that by heating such a culture for five minutes at 60° Centigrade the bacilli were killed and the broth sterilised. These matters need not therefore be again dwelt on.

The series of experiments now in question included 26 guinea-pigs, all of which were inoculated in right inguinal region with *human* tubercle on January 30th, 1890. By February 27th all of them presented at the site of inoculation enlarged caseous glands; the caseous matter from which when examined revealed many tubercle bacilli. These 26 guinea-pigs were then dealt with in four groups, as follows:—

(*a.*) Eight animals were injected with a mixture (sterilised) of broth culture of tubercle bacillus, and of broth culture of bacillus pyocyaneus that had been incubated for 10 days at 37° C.

(*b.*) Eight animals were injected with sterilised broth culture of tubercle bacillus alone.

(*c.*) Eight animals were injected with sterilised broth culture of bacillus pyocyaneus alone; and—

(*d.*) Two animals were kept for control.

These injections were commenced on February 27th, and the amounts used for each guinea-pig were,—

In group (*a.*) three divisions of a Pravaz syringe of sterilised broth culture of tubercle bacillus (undiluted) and three divisions of sterilised broth culture of bacillus pyocyaneus *diluted* with five parts sterile salt solution to one of the culture.

In group (*b.*), each guinea-pig received three Pravaz divisions of sterilised broth culture (undiluted) of tubercle bacillus.

And in group (*c.*), each received three Pravaz divisions of the *diluted* sterilised broth pyocyaneus culture.

Re-injection of the guinea-pigs of all three groups was performed on February 28th, March 3rd, 4th, 5th, 6th, 7th, 9th, 11th, 12th, 13th, 14th, 16th, 18th, 20th, 24th, 26th, 28th, 31st, April 1st, 3rd, 4th, and 6th.

During the second half of April the guinea-pigs of group (*a.*) and of group (*b.*) began to die. They all had enlarged glands and open suppurating sores at the site of their tubercular inoculation in the inguinal region. On *post-mortem* examination of each one that died, there was found tubercle in the liver, spleen, and lung. By the end of April, one of the control guinea-pigs, six guinea-pigs of group (*a.*), six of group (*b.*), and two of group (*c.*) had died. On May 5th the second control guinea-pig, the remaining two of group (*a.*), the remaining two of group (*b.*), and one of group (*c.*) also died; all with marked visceral tubercle. The five remaining guinea-pigs of group (*c.*), however, continued living till June 8th. But from this time onwards they began to get very thin and died one after another; so that by the end of June they had all succumbed.

Although this result was not altogether satisfactory, it, at any rate, sufficed to show that the guinea-pigs which had been injected with sterilised broth culture of bacillus pyocyaneus *alone*, were able to resist the fatal tendency of their tubercular process longer than guinea-pigs injected with the other materials experimented with; and that therefore injection of the sterilised pyocyaneus culture did as matter of fact exert some restraining influence on the progress of the tubercular process. That this was so was further indicated by the circumstance that in some of these "pyocyaneus guinea-pigs" the tubercular process in the viscera

positive results.

was not by any means so extensive as in the other experimental animals. In two of them, for instance, the spleen though enlarged showed, nevertheless, distinct signs of the tubercle having healed; their spleens did not, as in the other animals, contain any of those distinct tubercular caseous nodules that the typically tubercular spleen of the guinea-pig exhibits, but on the contrary showed patches of pale grey spleen tissue which even to the naked eye (and still more readily under the microscope) could be recognised as cicatrices. The livers also of these animals contained fewer of the caseous and bile-stained patches of tubercle found commonly in tubercular guinea-pigs at similar interval (four months) after inoculation.

This experiment, therefore, notwithstanding that it had been carried out with small doses only of sterilised broth culture of bacillus pyocyaneus, was distinctly of an encouraging nature, and repetition of it therefore with larger doses of this culture appeared worth trying. Accordingly the following series was undertaken.

Experiment repeated:

On October 2nd, 1890, eight guinea-pigs were inoculated with caseous tubercular matter (full of tubercle bacilli) from a lymph-gland of a *calf*. Eighteen days afterwards, *i.e.*, October 20th, all had, at the seat of inoculation (right side), slightly enlarged firm inguinal glands. Six of the eight were now subjected to injection in the left groin of three Pravaz divisions of *undiluted* sterilised broth culture of the bacillus pyocyaneus that had been incubated for ten days at 37° C. And this injection was repeated in the same dose on October 21st, 23rd, 24th, 26th, 28th, 29th, 30th, 31st, and on November 2nd, 4th, 5th, and 6th.

Both the control guinea-pigs died, on October 26th and October 28th respectively. They had open suppurating sores at the seat of the tubercular inoculation; and, as well, extensive visceral tuberculosis of the lungs, the spleen, and the liver; as also of the sternal, bronchial, mesenteric, and pelvic lymph-glands.

Of the six guinea-pigs injected with sterilised pyocyaneus culture, one which died on October 31st showed in the viscera a few tubercles only; a far less extensive tuberculosis than observed in the control guinea-pigs. The other five experimental guinea-pigs remained alive, and two months later examination showed these animals to be fairly well nourished. Their inguinal glands were at this date observed to be enlarged, but only one of them had any sore at the seat of the primary inoculation. In none were the inguinal glands larger than small filberts. They were now, January 6th, 1891, all killed. *Post-mortem*, it was found that their livers contained a limited number of grey dots which proved to be tubercle; their spleens were slightly enlarged, the surface looking granular; their lungs were slightly congested, but in the lung of one animal only was a grey tubercle (a single one) to be detected.

with same results.

As to this series, then, no doubt can be entertained of the fact that repeated injection of the sterilised pyocyaneus culture had a decided effect in delaying the process of tuberculosis. The two control guinea-pigs died, be it noted, of extensive tuberculosis in about four weeks; so that the tubercular material used for their inoculation must needs have been of a virulent character. Nevertheless in the five other guinea-pigs injected with pyocyaneus culture the tubercle process was strikingly retarded, or even arrested.

In an additional series, four guinea-pigs were inoculated on April 19th, 1891, with tubercular matter derived from a guinea-pig that had succumbed to extensive visceral tuberculosis induced by inoculation of material of *human* origin. In 15 days they all had slightly enlarged inguinal glands; but these were firm and none appeared to be softening. These four guinea-pigs were then (May 4th) injected with the sterilised

broth culture (undiluted) of bacillus pyocyaneus, each receiving three Pravaz divisions. This injection was repeated on the following day, May 5th; and on May 6th, 7th, and 9th they each received five Pravaz divisions, followed by injection of the same quantity again on May 11th, 12th, 13th, 14th, 16th, and 18th, to be further repeated on May 20th, 22nd, 24th, 26th, and 28th.

Unfortunately on May 30th these four guinea-pigs, as well as others not subject to experiment, were found dead. They had succumbed to what looked like pneumonia, a malady which from time to time, particularly during hot weather, causes extremely unpleasant breaks in some of our experiments. But the *post-mortem* examination of the animals subjected to the above pyocyaneus injection while showing in each large caseous glands at the seat of the primary inoculation; showed also the spleen only very slightly enlarged and granular, and in the liver merely a few minute grey spots. The lungs, as was to be expected under the circumstances of the inter-current pneumonia, were much congested; but no tubercles could be discovered in them. In a word, I am decidedly of opinion as regards these guinea-pigs, that the pyocyaneus inoculation had delayed the development of their tuberculosis. For I should certainly have expected guinea-pigs subjected to tubercular inoculation and with the same kind of material, but not afterwards injected with pyocyaneus material, to have exhibited after 41 days considerably more advanced tuberculosis of the viscera (notably of the spleen and liver) than was the case in the above four guinea-pigs.

II.—Experiments with Cows and Calves.

Tuberculisation of the bovine animal:

These experiments were now extended to the bovine animals. For this purpose, therefore, inoculation of healthy cows and calves with bovine tubercular matter was undertaken.

On May the 4th four cows and two calves were inoculated, each subcutaneously on the inside of the thigh, with the caseous matter of advanced tubercular disease of the lung of a *cow*. The caseous matter in question teemed with tubercle bacilli.

On June 20th one of the calves had a small, firm, enlarged gland in the groin, about the size of a small walnut; the other calf had a cord-like thickening at the seat of inoculation. But in neither of the cows could any enlarged glands be discovered, though one had also a corded swelling at the seat of inoculation. The enlarged gland of calf No. 1 was now excised, and showed in the centre a white necrotic mass, but without softening. This necrotic mass examined microscopically in cover-glass specimens and in sections, contained an abundance of tubercle bacilli. Used for the inoculation (subcutaneously) of six guinea-pigs, material from this necrotic mass produced in all of them typical tuberculosis in the normal time.

The four cows and two calves, five months after their inoculation with tubercular matter, all appeared normal and extremely well nourished. They did not indeed, for this very reason, seem to be suitable for testing the effect of injection of sterilised culture of the bacillus pyocyaneus; it being very doubtful whether tuberculosis of the viscera had been induced in any of them. They were accordingly killed on the 1st and 2nd of October, and *post-mortem*, the following conditions were observed:—

Cow No. 1.—Nothing abnormal at the seat of inoculation. The *liver* contained a few whitish caseous tubercles; one as big as a filbert, the others much smaller. The *pleura of the right lung*, in its upper lobe, was covered with numerous tubercular nodules and patches, most of

them grey, a few caseous. These tubercular patches were generally isolated, though in some places closely packed and even confluent. The right *costal pleura* showed also a few grey tubercular patches. The *spleen* was free from tubercle. In the pelvis was a large caseous gland, as large as a medium-sized potato.

Cow No. 2.—No tubercle in any part; the site of inoculation not visible.

Cow No. 3.—In good condition; all organs free from disease.

Cow No. 4.—At the seat of inoculation a small firm gland. The upper lobe of the *left lung* contained numerous tubercles, some grey others caseous; as did also the *pleura* of that lobe, and the substance of all lobes of the lung. The *liver* was free from tubercle.

Calf No. 1.—At the seat of inoculation, from which, on 20th June, an enlarged gland had been removed, there were two big caseous glands. The *liver* contained three small grey tubercles, of the size of millet seeds. In the left *lung* there was one caseous tubercle of the size of a pea; and in the right lung there were three small grey tubercles of the size of millet seeds.

Calf No. 2.—Was in good condition. At the seat of inoculation there was a firm gland of the size of a filbert. No disease in any of the viscera.

In all instances in which the glands or viscera are referred to above as containing tubercle, this diagnosis was confirmed by the microscope; tubercle bacilli being demonstrated in cover-glass specimens and in sections. Inoculation too of guinea-pigs with the caseous matter of the pulmonary tubercles from cows Nos. 1 and 4 produced typical tuberculosis in these rodents.

failure of experiment.

From these experiments it is evident that subcutaneous inoculation of cows and calves with virulent bovine tubercular matter (each of the six animals received a large dose), is not to be depended on to produce tuberculosis; a result the very reverse of that obtained with rodents. Two out of the four cows remained quite free from tubercle after the lapse of five months; while in the other experimental animals (two cows and two calves) the tubercular process that resulted was comparatively of a mild character. I must confess that this outcome of my experiments on the bovine animal was wholly unexpected by me; but I am in a measure consoled for my disappointment by the reflection that if my intended pyocyaneus injection of these cows and calves had been carried out, the post-mortem condition of the animals would have tended to an entirely erroneous conclusion. Thus, it might have been incorrectly inferred that in cows Nos. 2 and 3, tubercular disease had been prevented, whereas in reality these animals had escaped the disease altogether.

I am at present looking for suitable cows affected naturally with tubercle, in order to test them with the pyocyaneus injection. There is, however, difficulty as to this, from the need to select for such purpose cows which are not too far advanced in the tubercular process; for it is hardly possible to expect a satisfactory result from the pyocyaneus injection of animals which are affected with advanced tuberculosis. Meanwhile living cows which can be for certain diagnosed as tubercular without being at the same time subjects of advanced tuberculosis, are, so far as I have been able to ascertain, not at all easily obtained.

In the microscopic examination of the tubercular materials referred to in this report I have been very ably assisted by Dr. Cautley.

No. 4.

Report on the Chemical Pathology of Diphtheria and of Infective Endocarditis: with an account of Diphtheritic Palsy, experimentally produced by the Chemical Poison of Diphtheria; by Sidney Martin, M.D., F.R.C.P.

The investigation of the Chemical Pathology of Anthrax recorded in my two last Reports,* demonstrated the means by which the bacillus anthracis, the primary infective agent, acts. When inoculated into the animal body this bacillus begins to locally digest the proteids, and the products of this digestion in turn cause a local œdema containing in solution (like other pathological effusions) a large quantity of proteids that are outside the active metabolism of the body; proteids, therefore, that are ready to serve as a suitable food for the bacillus.

The absorption by the animal body of the digested proteids from the local œdema, as well as from the other parts of the body to which the bacillus has been transferred and wherein it has grown, produces the symptoms of the disease; and it is to the gradual accumulation of the poisonous "anthrax base" that the stupor ending in coma and death is due. The poisonous bodies that are the specific products of the bacillus, are readily recognised either in a cultivation or when separated from the tissues of an animal that has died of the disease.

The general conclusion from my study of the chemistry of anthrax was that two classes of products are formed by the bacillus from the proteids of the anthrax animal; one product belonging to the digested proteids, viz., albumoses; the other, a non-proteid body, being a definite organic base having a specific action.

I.—THE CHEMICAL PATHOLOGY OF DIPHTHERIA.

With these results in mind, the work on diphtheria was begun, but a somewhat different method of investigation was adopted. The tissues of patients dead of diphtheria were chemically investigated, *before* an attempt was made to isolate from culture media the products therein of the bacillus diphtheriæ. In the search, moreover, for specific poisons in diphtheria, the aim was perhaps theoretically simpler than in the case of anthrax. For in diphtheria there is the peculiar palsy which follows the disease and is so closely associated with it that it is more properly considered a symptom and not a sequela. All facts point to the diphtheritic membrane as the seat of origin of the disease, so that this membrane was examined chemically as well as the blood, the spleen, and the kidneys.

* Reports of the Medical Officer of the Local Government Board for 1889 and 1890.

A.—The Diphtheria Tissues of the Human Subject.

In all eight cases of diphtheria, every one of them fatal in children, were thus dealt with. The facts respecting six of the eight post-mortems are shown in the following table :—

No. of P.-M.	Examination, Hours after Death.	Age of Patient.	Duration of the Disease.	Site and Extent of the Local Diphtheria.	Other Lesions noted.
1	3¼	1 year -	6 days -	Laryngeal.	——
2	3	5 years -	8 „ -	Nasal pharyngeal and laryngeal	——
3	6½	4 „ -	10 „ -	Tonsillar - - - -	1 small suppurating gland below jaw.
4	12	1 1/15 „ -	9 „ -	Pharyngeal and laryngeal.	——
5	4	3½ „ -	7 „ -	Pharyngeal and laryngeal -	Broncho-pneumonia.
6	13½	8 „ -	4 „ -	Nasal-pharyngeal.	——

Cases 2, 4, 5, and 6 showed at the post-mortem examination the typical diphtheria membrane, and microscopical examination of samples exhibited the typical structure of this membrane with the presence of the bacillus diphtheriæ in its superficial layers. Case 6 might be classed as one of malignant diphtheria from its rapid course with high fever and great prostration. Cases 1 and 3 differed from the others in the following respects. In Case 1 there was at the post-mortem nothing visible to the naked eye as the cause of death. The pharynx and fauces were normal. There were indeed a few small erosions on the under surface of the epiglottis and in the upper part of the larynx; but there was no membrane, nor had membrane been observed during life. On a microscopical examination a few minute flakes of membrane were found in the larynx in the neighbourhood of the erosions, with the diphtheritic bacillus near the free surface of the flakes. During life this child had suffered from a croupy cough, and died in dyspnœa after tracheotomy. This case resembles those commonly ascribed to "croup." Case 3 showed at the post-mortem congestion and erosion of the tonsils and congestion of the pharynx; there was no membrane, and cultivations of the throat yielded only micrococci and not the bacillus diphtheriæ. Membrane was, however, present in the throat on admission into the hospital. These six cases, therefore, represent the different classes of diphtheria cases which die: Namely, those with typical membrane in the nose, pharynx, or larynx, as Cases 2, 4, 5, 6, some of which may have broncho-pneumonia as well; those (Case 1, for instance) in which the disease is limited to the larynx, and in which membrane is discovered only microscopically; and lastly cases (Case 3) in which the membrane, as such, has disappeared, leaving a congested condition of the throat, and in which the disease is associated with a secondary pus infection of the lymphatic glands below the jaw.

(*a.*) *Method of Examination of Diphtheria Tissues and the Chemical Products obtained.*

In the separation of poisonous products from the tissues or from a culture of a micro-organism, the same method is applicable except that the culture has first to be freed from bacilli. Thus, as regards the tissues in question, the spleen, as also the blood and other organs, were finely minced and placed in rectified spirit, and the mixtures were allowed to stand until all the ordinary proteids were coagulated. They were then filtered and the residue extracted with cold distilled water until nothing more dissolved. The several extracts were mixed together, evaporated at 35° C.

to a small bulk, and thrown into absolute alcohol. This precipitated most of the albumoses, some deutero-albumose remaining in solution. After standing, the alcohol was poured off and the liquid evaporated to dryness at a low temperature, and the residue extracted by absolute alcohol until nothing more dissolved. The residue left after extraction with alcohol was deutero-albumose with mineral salts. All the proteid was mixed together, dissolved in a small quantity of water and precipitated again by alcohol; the process being repeated several times to remove any traces of bodies soluble in alcohol and the excess of mineral salts. At the last precipitation the precipitate was allowed to stand under alcohol for six weeks to two months, after which the alcohol was poured off and the precipitate dried in vacuo. By this method the products were from first to last in contact with no reagent but pure alcohol, and were never heated to above 40° C. The resulting product is a light, yellowish brown powder, which yields nothing to alcohol, ether, or chloroform, and which keeps indefinitely if preserved in a dry atmosphere. It is soluble in water, cold or boiling; its solution being yellowish, sometimes faintly acid or nearly neutral. It consists almost solely of deutero-albumose, a small amount of proto-albumose being also present. There is no peptone in it. It gives all the ordinary reactions of proteids and a well-marked biuret reaction. It is completely precipitated from solution by saturation with ammonium sulphate; nitric acid gives a slight precipitate which is greatly increased if sodium chloride be added to the solution. In fact this proteid powder is chiefly deutero-albumose, giving reactions similar to those of peptic deutero-albumose.

The alcoholic extract of the tissues is strongly acid. It contains an appreciable quantity of free fatty acid, and also of another organic acid which is separable from the first by its insolubility in chloroform. This organic acid is readily soluble in water and in absolute alcohol; it is quite insoluble in ether, chloroform, and benzene. It is a yellowish amorphous body, which becomes a deep brown on being made alkaline. Its further chemical characteristics have not been at present investigated.

In the tissues of none of the diphtheria patients in question was there any organic base or alkaloid present.

(*b.*) *Amount of Chemical Products present in the Tissues in Diphtheria.*

An attempt was made in some of the cases examined to estimate the relative amount of albumoses and alcoholic extract (that is, organic acid) present in the blood and spleen. The weights given are only approximate, as there is such a great loss of the substances during purification.

No. of P.-M.	Seat of Local Diphtheria.	Albumoses, in Grammes, obtained from			Alcoholic Extract (Organic Acid) obtained from Blood and Spleen.
		Blood and Spleen together.	Blood alone.	Spleen alone.	
1	Tonsils - -	0·974*	—	—	0·271
3		0·5955	—	—	—†
4	Pharynx and larynx	—	0·149	—	0·107 (Blood alone).
5	Pharynx and larynx	0·805	0·450	0·355	0·455
6	Nose-pharynx -	—	Trace -	0·715	—†

* And kidneys.

† The alcoholic extracts from cases 3 and 6 (spleen) were weighed together; the weight being 0·528 gramme.

The points of interest arising from these results are the following:—

First.—That the albumoses are always associated with the presence of the organic acid, and that the amount of albumoses is much greater than that of this acid. This is a fact of great importance in considering the relative physiological action of the two classes of substances. It will be noticed too that in Case 1, which occurred in a child only a year old, nearly a gramme of albumoses was obtained from the blood, spleen, and kidneys, which, owing to the large amount lost in purification, represents a much larger quantity really existing in the body.

Secondly.—In two of the cases the greatest quantity of albumoses was present in the spleen. In case 1, for instance, in which the organ was not enlarged. And also in case 6, in which only a trace of albumoses was found in the blood, where no less than 0·715 grm. was obtained from the spleen. Similarly from the spleen a larger amount of the acid body was obtained than from the blood. The spleen is, in fact, the chief repository of the diphtheritic poison in the animal body.

Thirdly.—It is also noticeable that in Cases 1 and 3, to which attention has been already drawn as differing from the typical cases of diphtheria seen on the post-mortem table, the same bodies were found as in the typical cases of diphtheria; and it may be at once stated that the results of the physiological action of these bodies were the same in all the cases. Cases 1, 3, 5, and 6 were those in which the products were used for physiological experiments.

We might, therefore, sum up the chemistry of the tissues in diphtheria by saying that two classes of substances are present which are abnormal to the body; one belonging to the group of digested proteids, namely, albumoses; the other an organic acid. Contrasted with anthrax it is seen that whereas the bacillus anthracis produces albumoses and an organic base (alkaloid), in diphtheria we have albumoses and an organic acid. The albumoses of diphtheria cannot be distinguished by chemical tests from those of anthrax or of peptic digestion. Their physiological effect, a test more delicate than any chemical reaction, is the only method by which their specificity is made evident.

(*c.*) *Physiological Action of the Albumoses found in the Tissues in Diphtheria.*

1. *Albumoses subcutaneously injected.*

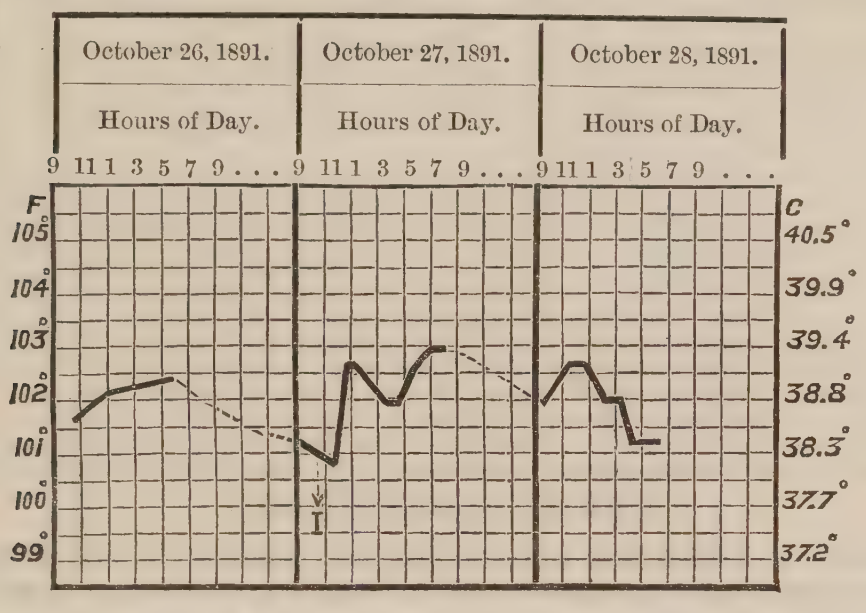
When subcutaneously injected, the diphtheria albumoses produce a local œdema. It is a clear œdema unaccompanied by any naked eye congestion of the part, and not followed by any necrosis. In one case this œdema came on in 2 hours, spread rapidly for 24 hours, and then rapidly diminished; so that in 36 hours it had practically gone and left no trace behind.

A more important effect is that on the body temperature. The subcutaneous injection of 0·256 grm. per kilo of body weight in a guinea-pig produced only an irregularity of the temperature without well-marked rise, as is seen in the Chart I. This result is in marked

contrast to the similar experiment with anthrax and peptic albumoses, described by me in a previous report.

Chart I.

Guinea-pig, weighing 300 grammes, subcutaneously inoculated in the right thigh with 0·077 gramme of diphtheria albumoses. Dose per kilo. body weight of animal, 0·256 gramme.



I. Occasion of injection of diphtheria albumoses.

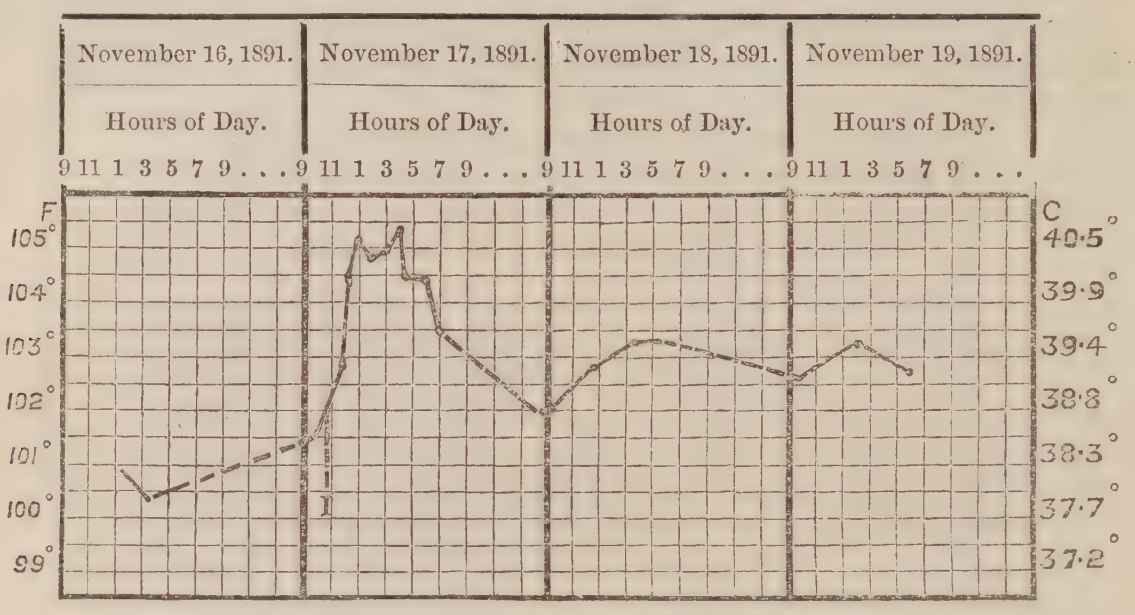
2. *Intravenous injection of Albumoses, single dose.*

As regards rabbits, it is necessary to premise that in all experiments on the effect of the intravenous injection of these proteid poisons, certain precautions must be taken in order to ensure that the animal used for experiment is a healthy one. My usual practice is to isolate an animal and to take its weight, then to observe its temperature three or four times daily for a week or more. If during this time the animal gains in weight, and if the rectal temperature does not at any time rise to 103° F., or does not for one day remain as high as 102·5° F., the animal is used for experiment. If such precautions are taken, both time and animals are saved, and greater accuracy in the experiment is secured. There is one disease in rabbits, viz., spinal curvature causing paraplegia, which is not excluded by the precautions I have enumerated. But this disease is a very definite one and readily recognised.

In one animal a single dose of 0·117 grm. per kilo. of body weight produced, as seen in Chart II. on the next page, a well-marked rise of temperature on the day of inoculation, and a slight degree of fever lasting four additional days. Nothing further happened to this animal. It did not get paralysed, and it was killed on the 94th day (13 weeks). The post-mortem examination will be discussed later. In another animal a dose of 0·122 grm. per kilo of body weight, produced a rapid fall of temperature and death in three hours. In this case, paralysis of the hind limbs occurred in one and a half hours, and was followed by coma. An examination made just after death showed a pinkish colouration of the lungs, due to congestion, and pallor of the spleen. There were no ecchymoses and no effusion. The blood was profoundly altered; it was dark and fluid, and was slow in coagulating. A small quantity put into a watch glass did not set for over 15 minutes. Normal rabbit's blood begins to coagulate in a half to one and a half minute. The

Chart II.

Rabbit, weighing 1,050 grammes, injected on a single occasion in the marginal vein of left ear with diphtheria albumoses, equal to 0·117 gramme per kilo. body weight of the animal. Killed in 94 days.



I. Occasion of injection of albumoses.

retardation of coagulation observed in this instance is not peculiar to death by diphtheria products, but is observed also after death from injection of the ordinary peptic albumoses when they are intravenously injected into dogs.

3. *Intravenous injection of Albumoses, multiple doses.*

The effects following the intravenous injection of the diphtheria albumoses in divided doses are much more important than in similar experiments with single doses. With multiple doses one imitates, imperfectly it is true, the course of events in the natural disease; and, as is an established fact, multiple small doses of a poison have a more powerful effect than a single large dose. In the following table the particulars are given of experiment in this way on five rabbits. The doses were given as a rule on successive days; in one case only on the same day.

Weight of Experimental Rabbit, in grms.	The Albumoses employed.			Death of Experimental Animal, in	Paralysis in
	No. of Diphtheria Case, whence derived.	No. of Doses administered.	Total Dose per Kilo. of Body Weight of Rabbit.		
No. 1.—1100 -	5	2	0·136	7 days -	3 days.
„ 2.—1970 -	5	2	0·153	11 „ -	6 „
„ 3.— 970 -	6	3	0·157	10 „ -	7 „
„ 4.—1565 -	3	2	0·100	Killed in 24 days.	20 „
„ 5.—1200 -	6	2	0·083	Recovery* -	19 „

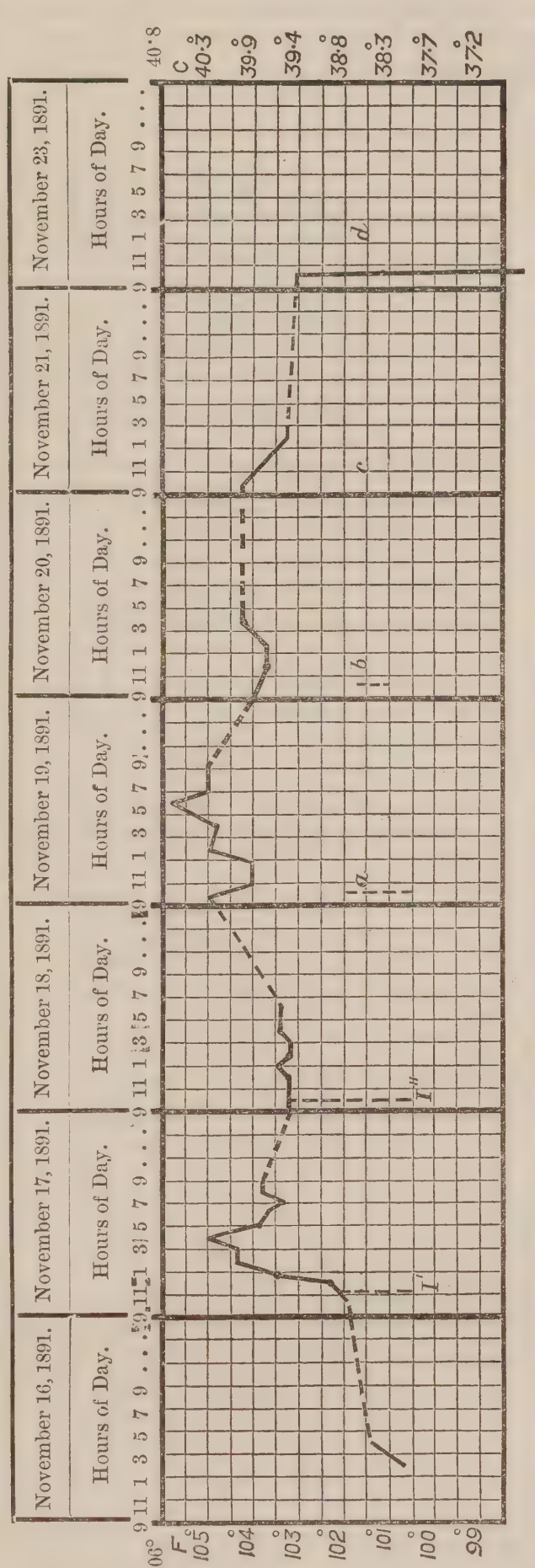
* This animal recovered almost completely from the diphtheria paralysis; but subsequently developed the paraplegia due to Pott's Disease, which is not uncommon among rabbits. It was killed on the 75th day.

(*a.*) *Fever.*—The first symptom noticed after the inoculation is fever, which in some cases is great and in some slight. In the first animal

the fever lasted during the seven days the animal lived, as is shown by the accompanying chart. (Chart III.)

Chart III.

Rabbit No. 1, weighing 1,100 grammes, subjected on successive days to intravenous injection (into marginal vein left ear) of 0·076 gramme of diphtheria albumoses from blood and spleen. Total dose = 0·136 gramme per kilo. body weight of experimental animal. Death on the seventh day.

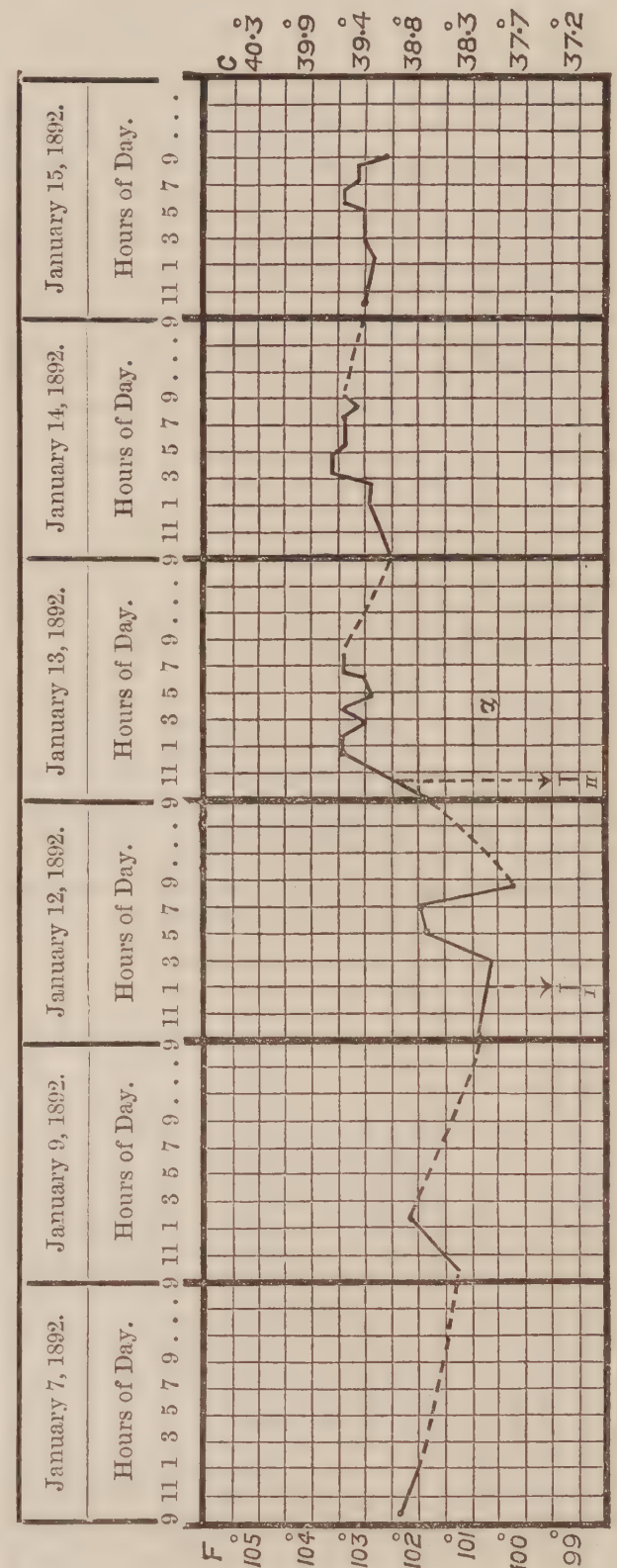


I'. Occasion of first injection: bodyweight of animal at this date, 1,100 grammes.
I''. " second injection.
a. On this day and at this hour paresis of left hind leg noted.
b. " the above paresis more marked: weight of animal reduced to 930 grammes.
c. " slight paresis of right hind leg, which was increasing next day.
d. " paresis of all limbs, especially those of left side. Died: temperature at death 86·45° F.; weight 970 grammes.

This is the only instance of sustained high temperature in any of the experimental animals. In the second rabbit, in which the two doses were given on the same day, the fever lasted only during that day and was very slight. In the fifth animal the fever lasted about three days after the inoculation; and it was moderate in degree, as is shown in the annexed chart. (Chart IV.)

CHART IV.

Rabbit No. 5, weighing 1200 grammes, subjected on successive days to intravenous injection of 0·05 gramme of diphtheria albumoses from the spleen. Total dose = 0·083 gramme per kilo. body weight of animal. Recovery from the paralysis.


January 7, 1892.
January 9, 1892.
January 12, 1892.
January 13, 1892.
January 14, 1892.
January 15, 1892.
Hours of Day.
9 11 1 3 5 7 9 ... 9 11 1 3 5 7 9 ... 9 11 1 3 5 7 9 ... 9 11 1 3 5 7 9 ... 9 11 1 3 5 7 9 ... 9 11 1 3 5 7 9 ...
F.
105° 104° 103° 102° 101° 100° 99°
C.
40·3° 39·9° 39·4° 38·8° 38·3° 37·7° 37·2°
I
I'
II
III
α
I. Occasion of first injection.
I'. " second injection.
a. Weakness of hind legs first noted.

The effect on the body temperature is therefore a very varying one. But whether these animals have slight fever or great fever, they all show a more definite symptom, that is, a paresis of the muscles.

(β.) *Paresis.*—In the *first* rabbit, for example, which had high fever, paresis of the left leg appeared on the third day, when it was observed to be not so much used as the right leg in jumping. The paresis was more marked on the fourth day; both legs were affected on the fifth day; and on the sixth day there was paresis of all the limbs. There was not, however, complete paralysis; for just before death the animal could still move when touched, although it only hobbled a few paces. The *second* rabbit showed paresis of the right fore leg on the sixth day, and on the ninth day this extended to the other fore leg. There was a general weakness of the muscles until death on the eleventh day. In the *third* rabbit, with a moderate degree of fever lasting six days, a general weakness of the animal appeared on the fifth day, and a definite paresis in the hind limbs on the seventh day. This increased till death. The *fourth* rabbit, which had moderate fever after injection with a smaller dose than the three just mentioned, showed only a slight general weakness for twenty days. On the twentieth day the paresis was definite in the hind legs; the animal was indisposed to move, and could not jump vigorously; the respiration was extremely rapid. The animal, however, recovered from the respiratory symptoms and was killed on the twenty-fourth day. The *fifth* rabbit showed a slight continued fever after the second dose, as illustrated in Chart IV., which passed off in five days. Weakness in the hind legs appeared in this animal on the second day. On the eighth day the hind legs were much weaker, especially the left, which was held slightly abducted (Fig. 1, Plate I.). The rabbit continued in this state till the nineteenth day, when almost suddenly it became much worse. Attempts at walking and jumping now resulted in an irregular movement which carried the animal some distance forward, when it stopped with limbs outstretched (Fig. 2, Plate I.). The breathing was now extremely rapid, and there were occasionally slight convulsive movements of all the limbs, which were possibly of respiratory origin. This serious condition of the animal passed off, and it regained a great deal of power in its limbs (Fig. 3, Plate I.).

The condition just described as passing off in this rabbit (No. 5), which had the smallest dose, is the condition in which the other animals which had the larger doses died. It is, so to speak, the culminating point of the paresis, which, although more marked in certain limbs, is always general, affecting the trunk muscles as well as those of the limbs. When it comes on with the larger doses it usually lasts 24 hours before the animal dies. It is, as shown by the post-mortem examination, partly respiratory and partly cardiac in origin.

From the injection, therefore, of the diphtheria albumoses a paresis of the muscles is produced which may be most marked in one limb, but is always general and progressive. It is associated with an affection of the respiration, as shown in the rapidity, or in some cases slowness, of breathing during the attacks described, and which may pass off if the dose be a small one. With this paresis there is no special wasting of the muscles; even when the limb of one side is more paretic than that of the other it does not waste. As regards loss of sensation I did not attempt to estimate it as the experimental animals were rabbits. No affection of the pupil was noted in any of these animals. With the large doses, the knee-jerks were found diminished after some days, but they never completely disappeared. When one hind leg was more paretic than the other, the knee-jerk on that side was diminished.

(γ.) *Loss of Weight.*—Although the muscles do not obviously waste, there is a general loss of weight, which is the more marked the larger the dose. This is shown in the following table.

Original Weight of Rabbit, in Grammes.	Weight at Death.	Loss of Weight.	Death in	Fever Period.	Dose, in Grammes, of Albumoses per kilo.
No. 1.—1,100 -	970	$\frac{1}{8}$th	7 days -	7 days -	0·136
„ 2.—1,970 -	1,520	$\frac{1}{4}$	11 „ -	1 day -	0·153
„ 3.— 970 -	530	$\frac{1}{2}$	10 „ -	6 days -	0·157

With the largest dose given, the wasting was enormous, being nearly one-half of the original body weight. This wasting is not proportional to the fever, as it goes on after the fever has subsided. This is seen in animals 2 and 3, in one of which, with fever lasting only one day, one quarter of the body weight was lost, and in the other, with fever lasting six days, nearly one-half of the body weight was lost. With the smaller doses given, although the paresis was well-marked and the respiratory troubles very manifest, the loss of weight, was much less than in the animals shown in the table. Thus the rabbit (No. 4) with the total dose of 0·100 gramme per kilo. of body weight, showed on the eleventh day a loss of one-tenth of its body weight, after which it rapidly recovered weight until it was killed (on the twenty-fourth day); while the animal (No. 5), with the total dose of 0·083 gramme per kilo. of body weight, showed in 18 days a loss of only one-sixtieth of its body weight, after which it rapidly surpassed its original weight by 100 grammes. Subsequently, however, it showed slight fluctuations in its weight. In these cases the loss of weight is observed to be proportional to the dose of albumoses and not to the fever.

(δ.) *Diarrhœa.*—This was a symptom noticed only with the largest doses. It may last several days, and is watery and non-sanguineous. For the rest, one of the most striking features of the action of these albumoses is their prolonged effect. The fever may last a long time, the paresis produced may be rapid in onset but is slow in progress, and the general wasting produced is slow and prolonged.

4. *Post-Mortem Examination of Experimental Rabbits.*

That the symptoms described are really due to the action of these diphtheritic albumoses is evidenced by the post-mortem examination. That the animals did not die from the accidental introduction of a pathogenous micro-organism is clear from the fact that neither a microscopical examination of the organs of the body nor cultivations of the blood and spleen on agar and gelatine, showed the presence of any such micro-organisms. The liver, spleen, and kidneys were, to the naked eye and to microscopical examination, normal. The lungs, lymph, glands, and suprarenals were normal. In only one instance was subcutaneous œdema found; that was in the first animal, in which there was a large amount of œdema over the abdomen. As this was absent in the other animals it was looked upon as an accidental effect of the poison. The albumoses used in inoculation were moreover free from micro-organisms; the mode of their preparation ensures this, since from their removal from the body until they are dried they are always in contact with an excess of pure alcohol, and when dried they are not touched except with

sterile instruments, and they are finally preserved in a sterile bottle in a dry atmosphere. All instruments, indeed, used in the experiments were sterilised, so that the effect of bacteria in producing the symptoms described is definitely excluded. But that the albumoses were acting in the body while the animal was alive is shown by the condition of the blood after death. It has already been mentioned that the blood was slow in coagulating in the animal which died in three hours after a single dose. In the rabbit (No. 3) which had the largest amount of the albumoses in three doses, the blood was found in a similar condition. The animal had died during the night, and blood drawn from the right ventricle at 10 a.m. was liquid, and of a lighter red than venous blood. In 25 minutes, at the temperature of the laboratory, a small amount placed in the watch-glass began to coagulate, and was only completely set in two hours. This slow coagulation of the blood, which is a well-known feature of the action of albumoses on the blood, showed that the diphtheria albumoses were actually present in the circulation, in this case ten days after inoculation. But even in the animal which was killed 24 days after inoculation, the blood was found slow to coagulate, commencing to set in about 15 minutes, when removed one hour after death. This condition, however, was not found in another animal which died in 11 days after the inoculation of two doses of 0·153 gramme per kilo. of body weight; but in this instance the two doses were given on the same day, a fact which, having regard to a difference in the rate of excretion in different animals, may signify that in this case the albumoses were not present in sufficient quantity in the blood to retard coagulation, though in sufficient amount to produce the other symptoms of diphtheria albumoses, viz., the paresis and loss of weight. The condition of the blood in these animals appears to me to be extremely important, as it helps to explain why diphtheria paralysis in the human subject can occur some time after the acute disease is past.

5. *Pathological Condition of the Nervous System.*

All parts of the nervous system were examined. In the first experiments an incomplete examination was made; the later experiments were, however, much more thoroughly worked out. The motor nerves were cut out with a piece of muscle attached, so as to admit of the examination of the intra-muscular branches. The only method which is of value in the study of peripheral nerve degeneration is staining the fresh nerve with osmic acid (so that the white substance of Schwann is stained black), and counterstaining with carmine to bring out the nuclei and axis cylinder.

(α.) *Motor Nerves.*—After the motor nerve, with the piece of muscle attached, has been stained in osmic acid, it is, along with its intra-muscular branches, separated from the muscle as far as possible.

Fig. 4, Plate II., represents one of the intra-muscular branches to the triceps muscle. It is seen that the nerve is stained black by the osmic acid, except at two points just before it divides into two branches. At these points the nerve is attenuated and degenerated. This appearance is typical of diphtheria degeneration in the nerves; its microscopic characters will be dealt with in reference to a similar specimen obtained from the same animal.

Fig. 5, Plate III., represents one of the branches from the anterior crural nerve to the vastus muscle, with its intra-muscular branches. Just before the branch of the nerve on the left of the drawing divides,

a segment of the nerve is unstained by the osmic acid. Similarly the other large branch shows an unstained segment. The different parts of the nerve were examined between the transverse lines. All the parts near the origin of the nerve were quite normal. The left branch was next split with needles from the part marked by the second transverse line to the end of the small branches. The microscopic appearances of the nerve-fibres are represented in Figs. 6, 7, 8, 9, and 10 in Plates IV. and V. At the upper part, the fibres were normal (Fig. 6); a little lower down they showed a breaking up of the white substance of Schwann, which was becoming thin there and but little stained by the osmic acid; while lower down still the white substance disappeared altogether, namely, at the segment of the nerve unstained by the osmic acid (Fig. 7). Beyond this the white substance again appeared, but it was very pale and granular and broken up (Fig. 8); lower down still it regained its dark colour (Figs. 9 and 10). The primitive sheath of the nerve was intact throughout; the axis cylinder in this particular instance was intact down to the spot at which the white substance completely disappeared; and even through this part, so that here the majority of nerve fibres consisted only of axis cylinder and the primitive sheath. Below the point at which the white substance had disappeared the axis cylinder was in many instances broken. This is illustrated in Fig. 11, Plate V., which shows two ruptures in the axis cylinder.

Fig. 12, Plate VI., shows the rupture of an axis cylinder from another nerve, which displayed similar appearances to those observed in the nerve in the vastus. When the axis cylinder is ruptured the upper end is often seen bulbous as in the figures, and both peripheral and central parts become wavy (Figs. 12 and 13). After such rupture of the axis cylinder the nerve fibre undergoes below the rupture the Wallerian degeneration, the features of which are well known, and consist of a breaking up of the white substance along the whole course of the fibre; the axis cylinder also degenerating, so that portions become isolated. Many of the fibres, however, below the segment of degeneration do not undergo degeneration, showing that the axis cylinder is intact (Fig. 10, Plate V.). The other large branch to the vastus (see Plate III.) showed a less degree of change, and the third branch showed the earliest stage of the degeneration, of which I shall speak later. It will be seen from the specimen in question that the degeneration affects primarily a transverse portion of the nerve. It is a degeneration of the nerve fibre itself. There is no interstitial change, no increase of nuclei, which, in fact, themselves undergo an atrophy in the most advanced part. The portion of the nerve fibre primarily affected is the white substance of Schwann, which breaks up and finally disappears. The axis cylinder itself may be unruptured when the white substance has completely disappeared; but it finally becomes ruptured, and the nerve fibre below the rupture undergoes the Wallerian degeneration. The different branches of the same motor nerve are affected to a varying degree, so that in an individual motor nerve there are many fibres which can still innervate the muscle owing to the integrity of the axis cylinder. This is one reason why the conditions observed during life is a partial and not a complete paralysis.

In the nerve to the vastus, which has just been considered, the degeneration is seen right across the nerve, but in many nerves the change affects only a few fibres lying side by side or a single bundle of fibres.

Fig. 14, Plate VI., shows a bundle of fibres from the phrenic nerve, and displays the attenuation of the white substance under a low power.

Above this the fibres were normal, below a few were commencing to undergo the Wallerian degeneration.

Fig. 15, Plate VII., shows a similar degeneration affecting a bundle of fibres in one of the anterior dorsal roots. It presented exactly the same characters as the phrenic nerve just described.

Fig. 16, Plate VII., shows the degeneration in the phrenic from another experimental animal, and is interesting as demonstrating how very partial this segmental degeneration may be. At one edge of the specimen the white substance is seen to be breaking up, and as one proceeds to the other edge the fibres show an increased breaking up of the white substance with its gradual attenuation and disappearance; one fibre shows the axis cylinder passing intact through the attenuated part.

The earliest stage of this change in the motor nerve is the breaking up of the white substance in a portion of the nerve, while the axis cylinder may still be unaffected. This is well seen in Fig. 17, Plate VII., of the nerve to the biceps muscle. And in this early degeneration it is not uncommon to find that the nerve above and below the affected portion is quite normal. In some instances, however, this early segmentation of the white substance is associated with rupture of the axis cylinder.

In Figs. 18 and 19, Plate VIII., are exhibited nerve fibres from the phrenic under a higher power. In these the attenuation of the white substance has occurred in the middle of a node: it may also occur at the node. Fig. 19 shows the axis cylinder attenuated in one part. The more minute changes in the nerve fibres may be studied in Fig. 20, Plate VIII., which represents nerve fibres from the phrenic. In the fibre on the left of the figure the white substance is seen granular and becoming attenuated from without inwards, while the axis cylinder can be traced as a straight line in the centre of the nerve fibre. In the next two nerve fibres the white substance shows similar appearances, but the axis cylinder is wavy and becoming attenuated.

There may be more than one portion of the same nerve affected by the degeneration, and when this is so the whole nerve is liable to degenerate towards the periphery. Fig. 21, Plate IX., shows a bundle of nerve fibres from the phrenic with two degenerated portions, one affecting only a few fibres, the other many. The nerve below is only slightly degenerated. In Fig. 22, which shows the nerve to the gastrocnemius, wherein there have been at least three degenerated portions right across the nerve, the later stages of this "interrupted multiple" degeneration may be seen. Many nerve fibres are here observed lying side by side, in most of which only a primitive sheath and nuclei are to be seen with a few badly stained droplets of white substance, and here and there a trace of the degenerated axis cylinder. In the companion figure (23) the change is not so complete, more white substance is seen, and the axis cylinder is more visible in fragments, although there is one axis cylinder which runs right through.

The *muscles* to which the nerves go are also degenerated, this degeneration being proportional to the degree of nerve change. For example, the gastrocnemius muscle above referred to showed an advanced fatty degeneration in minute granules, staining black with osmic acid. When the nerve degeneration is less, fatty muscle fibres are found mixed with normal ones, or only parts of fibres may be fatty; and when the nerve change is only slight there may be only longitudinal striation of a few fibres, or indeed the muscle may

appear normal. The very partial fatty degeneration of the muscle is evidently dependent on the fact that the axis cylinders of the nerve fibres are in many instances intact.

The *heart muscle* is, however, in all these cases in an advanced degree of fatty degeneration. This is illustrated by Fig. 24, Plate X., which shows some of the fibres of the heart muscle stained with osmic acid. On what this cardiac degeneration depends it is difficult to say, for I have not found extensive degeneration in the vagus nerve, but only a few degenerated non-medullated fibres. It possibly depends on the altered condition of the blood which has been already described, or, indeed, the diphtheria albumoses may have a special action on the heart.

(β.) *Sensory Nerves.*—The sensory nerves may be affected in a manner similar to the motor. Fig. 25, Plate X., shows the interrupted degeneration in the long saphenous nerve near the knee. This nerve showed five degenerated portions of a similar character to those described in the motor nerves.

(γ.) *Sympathetic Nerves.*—The trunk of the sympathetic may be similarly affected. Thus Fig. 26, Plate X., shows the part of the cervical sympathetic just above the third ganglion. The degeneration went right across the nerve, and is of the same character as in the motor nerve, except that here of course the axis cylinders are more profoundly affected than in the medullated nerve fibres. On each side of the region of degeneration there is an increase in the number of nuclei. Above it the nerve was normal, below many fibres were degenerated.

From the facts just recorded it is evident that the paresis observed is due to degeneration of the nerves themselves, and that any of the nerve fibres in the body, whether medullated or non-medullated, may be thus affected.

(δ.) *Central Nervous System.*—Sections of the spinal cord, medulla and pons, stained by Marchi's, Weigert's, and Pal's methods, showed no degeneration either of the nerve fibres or of the cells. The cells of the anterior cornua of the spinal cord were normal, showing no fatty degeneration, excessive pigmentation, or vacuolation.

It has already been stated that in rabbits which have a *single* large dose, although they show fever, there is no paralysis. One animal which received subcutaneously 0·084 gramme per kilo of body weight, was killed in 115 days, and another which had intravenously a dose of 0·117 gramme per kilo of body weight was killed in 94 days. When killed, both were fat and well-nourished. On microscopical examination it was found that in both animals the phrenic nerves and the small branches of the motor nerves showed well-marked degeneration with rupture of a few axis cylinders; but in neither was there well-marked Wallerian degeneration below the degenerated portion. The heart was in each instance fattily degenerated. A single dose of the poison, therefore, although during life its effect had apparently passed off and had produced no paralytic symptoms, was found after death to have left a definite nerve lesion which had not been repaired.

6. *Distribution of Nerve Lesions.*

The distribution of the nerve change in one of the animals is represented by diagrams in Plates XI. and XII.

Fig. 27, Plate XI., shows the anterior crural and sciatic nerves of *one leg*. The normal parts are coloured black and the degenerated a lighter colour. It will be seen that all the motor nerves investigated showed a greater or less degree of degeneration. The change was most marked in the nerves of the sartorius, the vastus, and semi-tendinosus; it was less marked in the remaining motor nerves. In the long saphenous nerve, a sensory one, there was also well-marked degeneration. Transverse sections of the trunk of the sciatic nerve were normal. Below this point the whole nerve was teased out and was found normal. The fact is clear therefore that the degeneration affects the terminals of the motor branches and not the main trunk. There may be one or two degenerating fibres in the sciatic nerve if the spinal nerve roots are affected, but in this particular instance the sciatic nerve was normal.

Passing to the *trunk*, still in the same animal, one of the large branches to the psoas muscle showed well-marked degeneration. A cutaneous nerve of the abdomen was found normal. Of three pairs of spinal roots examined, one in the cervical, one in the dorsal, and one in the lumbar region, degeneration was found in only one anterior root in the dorsal region; the remainder of the anterior roots and all the posterior roots were normal. The spinal ganglia were also normal.

In the *arm* nerves, Fig. 28, Plate XII., the branches of the musculo-spiral to the triceps and to the flexor muscles of the fore-arm showed well-marked degeneration, while the branches of the brachial plexus to the pectoralis and to the biceps showed early degeneration. The musculo-spiral examined just above the origin of the branches to the triceps was normal. The phrenic showed degeneration; as did the recurrent laryngeal, but the trunk of the vagus in the neck was normal. The cervical sympathetic showed well-marked degeneration at the lower part, while above it was normal; and in the head, branches of the third nerve to the eye muscles showed well-marked degeneration.

From this it is seen how widespread is the change in the peripheral nerves, whether cerebral, spinal, or visceral, as the result of the injection into the circulation of so small a dose as 0·1565 gramme (in two doses) in a rabbit weighing 1,565 grammes, which is a dose of about 2½ grains in a rabbit weighing 3½ lbs.

7. *The observed Nerve-degeneration in the Experimental Animals in its relation to the Changes in the Nervous System in Diphtheria Palsy in Man.*

The experiments show most clearly that the diphtheria albumoses, although fever-producers, are nerve poisons, selecting the pheripheral nerves for their action, just as strychnine selects the motor cells of the cord for its action. I take it that with single doses the full amount of injury to the nerves that they could produce had been already accomplished, and that the degeneration was not progressing when the animals were killed. On the other hand the successive introduction of small doses into the circulation is able to keep up the action on the nerves so that a visible affection of motility results. It is possible, therefore, that in cases of diphtheria in man which recover without visible palsy, some of the nerves may be nevertheless degenerated, which would account for delay of convalescence that is common in such cases.

The fact that the diphtheria poisons isolated by me produce a nerve degeneration led to an investigation of the condition of the nerve in fatal cases of diphtheria in the human subject. Although this has

probably been done before, I can find no reference to it in the literature of Diphtheria.

Two fatal diphtheria cases were examined: in one of them the disease had lasted five days, in the other four weeks. The second, from its prolonged course, was a very favourable case for examination. The method used was that I have already described, viz., staining the nerve with osmic acid, and counter-staining in some cases with carmine.

Case I.—A female, æt. 5, admitted to University College Hospital, under the care of Dr. Ringer, suffering from pharyngeal and laryngeal diphtheria. The disease proved fatal in five days, dating from the onset of symptoms. At the *post-mortem*, the fauces, pharynx, larynx, trachæa, and bronchi were covered with false membrane. There was some pneumonia of the left lung. A microscopical examination of the heart, diaphragm, and the right phrenic nerve was made.

(α.) *Heart.*—Muscle normal; no fatty degeneration of the fibres.

(β.) *Diaphragm.*—Muscle normal; no fatty degeneration.

(γ.) *Right Phrenic Nerve.*—A small branch in the diaphragm showed a well-marked degenerated portion, the degeneration being of the same nature as that I have already fully described. The white substance of the nerve-fibres was broken up and attenuated, and in a few fibres the axis cylinder was ruptured. Examined in the middle of its course in the thorax, the phrenic showed some fibres with localised attenuation of the white substance in several parts along their length. These fibres presented appearances similar to those represented in Plate VIII., Fig. 18.

Even in five days, therefore, the diphtheria poisons are capable of producing a nerve degeneration in man.

Case II. was noticeable from the fact that the patient lived 27 days from the onset of the disease.

It occurred in a male aged 19 years, admitted to University College Hospital under the care of Dr. Poore. Membrane was present in the throat on the third day of illness: it extended to the nose on the ninth day, but had disappeared at death. There was slight paralysis of the palate on the ninth day of disease, and the knee jerks disappeared on the twenty-first day. From the tenth day till death there was a large amount of albumen present in the urine. The patient died in dyspnœa.

The following parts were examined microscopically: the heart, the diaphragm, and the phrenic nerve; the right and left vastus externus and vastus internus, and the nerves to them; and the soft palate and the nerves supplying it.

As regards the muscles, the conditions observed were these:—

Heart.—A few of the muscle fibres were found in a state of fatty degeneration.

Diaphragm.—Some muscle fibres showed complete fatty degeneration; some were slightly affected; many were normal.

Right vastus internus.—Fatty fibres mixed with normal ones.

Right vastus externus.—A few fatty granules in some of the fibres.

Left vastus internus.—Very few fatty granules were found in the fibres.

Left vastus externus.—In the same condition as the left vastus internus.

In the *Palate.*—Some of the muscle fibres showed an advanced degree of fatty degeneration, some were less affected, and many were normal.

An examination of the nerves supplying the muscles gave the following results:—

Phrenic.—Two small branches were examined: one was found normal, while the other showed degeneration in an early stage, the white substance of the nerve-fibres being broken up and in part attenuated.

The nerve to the left vastus internus showed, in one of its branches (one only examined), a well-marked area of degeneration, of a nature precisely similar to that described as following the injection of diphtheria albumoses in rabbits.

The nerve to the left vastus externus showed, in one branch, two areas of degeneration. Fig. 21, Plate IX., might be taken as a representation of the condition found.

The nerve to the right vastus internus showed, in one branch, also two degenerated areas, the degeneration being more advanced than in the nerve to the left vastus internus. In some fibres the axis cylinders were attenuated, and in some ruptured: the nerve, indeed, was beginning to degenerate from the points specially affected to the periphery (Wallerian degeneration).

Of the nerve to the right vastus externus three small branches were examined. All showed two or three fibres which had lost their white substance in parts.

Nerves in the palate.—After being stained in osmic acid, portions of the palate were teased with needles, and the small nerves separated. One of these was obtained with two branches. It showed a degenerated area in the trunk; early degeneration in the two branches. Other small branches of nerves were obtained showing early degeneration.

The nerves from this case, indeed, showed exactly the same appearances as depicted in the plates at the end of this report. The condition here found in acute diphtheria is therefore confirmatory of the conclusion that the albumoses and organic acid found in the bodies of patients dead of diphtheria are the cause of the symptoms of diphtheria and of the nerve degeneration and palsy observed in that disease.

Since Déjérine's* work on the subject, it has been recognised that the paralysis following diphtheria is due to a parenchymatous degeneration in the peripheral nerves. But both before this period (1878), as well as since, many observers have described changes in the cells of the anterior cornua of the spinal cord, and some have gone so far as to ascribe all the neurotic sequelæ to a mild polio-myelitis. The symptoms, however, are not those of an affection of the anterior cornua of the spinal cord, as there is an absence of any special wasting of the affected muscles and of the reaction of degeneration. The changes that have been described as occurring in the cells of the anterior horns (such as fatty degeneration, vacuolation, pigmentation, atrophy) are probably only phenomena superadded to the change in the peripheral nerves; and the poison which produces a change in these nerves and fatty degeneration of the heart, may very possibly after a time affect the nutrition of the nerve centres, causing first fatty degeneration, and then atrophy of the cells. The great argument in favour of the nerve change in diphtheria being essentially pheripheral is the fact that sensation is affected, and that no changes have been observed in the posterior cornua of the cords, or in the sensory ganglia. In my experiments on rabbits the cord and spinal ganglia were found quite normal.

* Sur la paralysie diphthéritique, Archives de Physiologie, 1878.

The nature of the nerve change observed in the experiments with the diphtheria albumoses was first described by Gombault* as the result of chronic poisoning by lead in guinea-pigs. He called the change "*névrite segmentaire péri-axile*"; or a neuritis affecting the nerve-fibre around the axis cylinder. His animals showed no paralysis, and he left them alive six months or longer; with the result that, as his figures show, he had the appearances both of degeneration and of restoration in the nerve fibres.

It is clear from the changes observed in the nerves as a sequence to the injection of diphtheria albumoses, that the condition is one of simple degeneration; affecting first of all the white substance of Schwann which breaks up and finally disappears, and affecting later the axis cylinder, which becomes attenuated and finally ruptured in some fibres, so that below this ruptured axis cylinder the fibre undergoes the Wallerian degeneration, while the muscle fibre becomes fatty. Many of the nerve fibres which show a degenerated white substance of Schwann, do not show a ruptured axis; and this, combined with the fact that the small branches of the motor nerves are affected to a varying degree, and that the motor nerves of the body are not all in the same degree of degeneration at the same period, suffices to explain why diphtheria palsy is not a complete but a partial paralysis.

In the degenerated nerves in human diphtheria palsy, an increase of nuclei of the nerve fibres has been described, and also nodular swellings on the nerves formed of cellular elements.† These changes probably only indicate an attempt at repair of the nerve; they are not met with in the cases of simple nerve degeneration seen in the artificially produced diphtheria palsy.

Meyer, who very thoroughly examined a case of diphtheria palsy in man, gives figures which show quite clearly that the change in the peripheral nerves is a degeneration affecting only a portion of the nerve, such as I have described as occurring in the experimental rabbits. He discusses the nature of this change and refers to Gombault's work, but lays a great deal too much stress on the nodules which occurred on the nerves in the case observed by him.

(*d.*) *Physiological Action of the Organic Acid from the Tissues of Diphtheria Patients.*

When the organic acid found in diphtheria is injected in watery solution into the circulation of rabbits, it produces a moderate degree of fever which may last one to three days, or which may be extremely slight; but nothing further happens to the animal. It may indeed waste a little, but it does not get paralysed, even after a single dose of 0·155 gramme per kilo of body weight. Similarly two successive doses equal to 0·095 gramme per kilo. of body weight produced only slight fever on the days of inoculation, but otherwise no effect. No paralysis occurred in 24 days. A similar amount of dose of the albumoses suffices to produce a definite palsy. The animal in question was killed on the 24th day. The heart's blood coagulated in a normal manner, and all the internal organs of the body were normal in appearance. On microscopical examination, however, it was found that the heart showed

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* Gombault, Archives de Neurologie, 1880-81, p. 11.

† Meyer. Virchow's Archiv., Vol. 85, 1881, p. 181, &c.

well-marked fatty degeneration, although not to such a great extent as in the experiments with the diphtheria albumoses. There were a few fatty fibres too in the diaphragm, but the parts of the vastus, semimembranosus and gastrocnemius muscles examined were quite normal. The phrenic nerve was examined in its upper half and found normal, but the nerves to the semimembranosus, the vastus, and the gastrocnemius all showed the different stages of degeneration exhibited in Fig. 29, Plate XIII.

An experimental animal which received a single dose of the alcoholic extract (organic acid) equal to 0·043 gramme per kilo. of body weight, showed well-marked fever, but no paralysis. When killed 119 days later, it was fat and well nourished, but showed early fatty degeneration of the heart and diaphragm, and well-marked degeneration in the phrenic nerve.

Another animal which received intravenously a very large dose of the acid on successive days, the total dose being equal to 0·319 per kilo. of body weight, showed no fever, paralysis, or loss of weight. As the dose given was more than twice the lethal dose of the albumose, the experiment shows how very little poisonous the organic acid is.

The organic acid therefore found in the bodies of diphtheria patients is, like the albumoses, a nerve poison, capable of producing the same anatomical change in the nerves, though it is not nearly so toxic as the albumoses. And it is not surprising that both the toxic bodies found in a specific disorder should have a similar action; it would indeed be more surprising if their physiological effects were different.

Having dealt with the chemistry and physiological action of the toxic bodies present in the bodies of patients dead of diphtheria, I pass now to consideration of the chemical composition of the diphtheria membrane.

B.—The Diphtheria Membrane.

Chemical examination of the diphtheria membrane presented some difficulty owing to the lack of material. Membrane removed during life with clean forceps, or a cast of the trachea coughed up after tracheotomy, was placed directly into absolute alcohol, partly to preserve it and partly to kill any micro-organisms present. It was after a varying time removed from the alcohol and extracted with sterile 10 per cent. NaCl solution. The membrane formed a gelatinous mucoid-looking mass in the salt solution, and as this would not in its then condition filter, it was further largely diluted before being passed through a Chamberland's filter. The filtrate was next dialysed till all the salt was removed, concentrated at a low temperature, and precipitated by alcohol. The precipitate which consisted only of proteid matter was used for experiment. Without going into the chemical details, the diphtheria membrane contains the following proteids: Namely, one almost insoluble in saline solutions at the ordinary temperature, which is the fibrin of the membrane; others extracted with saline solution and consisting of a large quantity of hetero-albumose which is precipitated by dialysis; and two other albumoses in traces, namely proto- and deutero-albumose. The presence of these bodies shows that the membrane is in a process of digestion, hetero-albumose being the first product from the fibrin, proto- and deutero-albumose the final products. Practically nothing is extracted from the membrane by

alcohol; the acid body that was found in the tissues, though to be found also in the membrane, is present only in minute quantities.

Physiological Action of the Chemical Ingredients of Diphtheria Membrane.

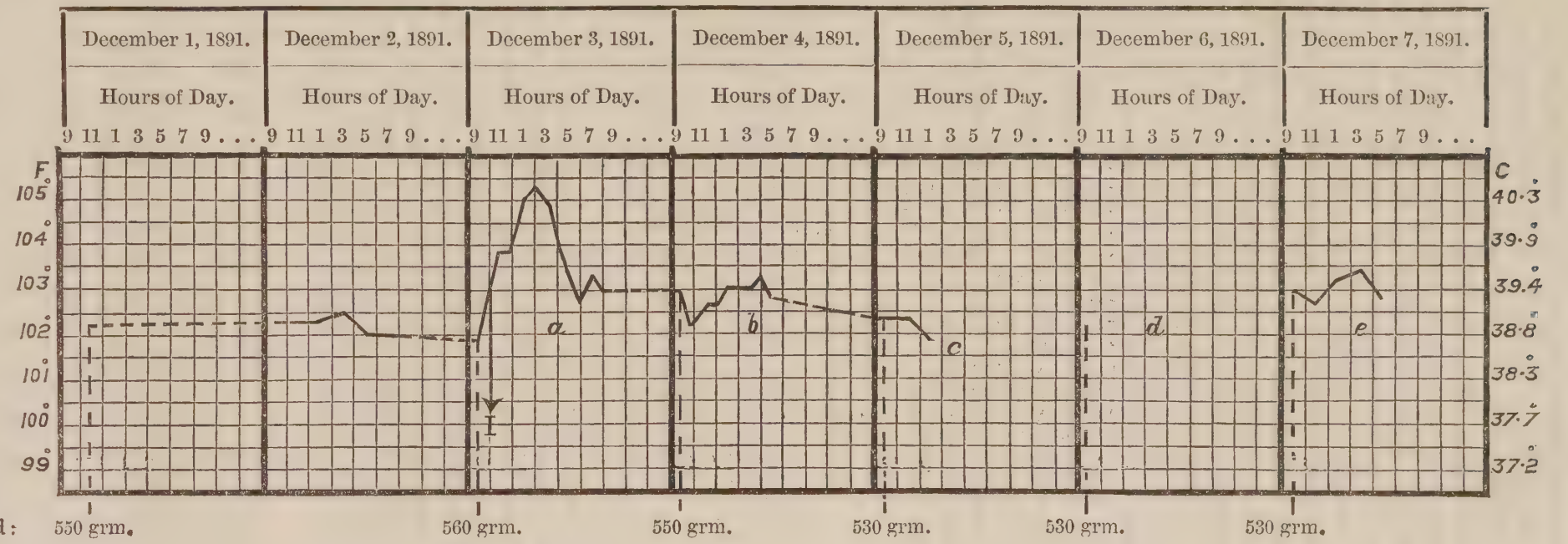
The extract of the membrane which was used for experiment was whitish yellow, not quite soluble in distilled water, and slightly alkaline. It consisted solely of proteid; there is but a mere trace of hetero-albumose, with trace also of proto- and deutero-albumose. 30 milligrammes were injected into a rabbit weighing 560 grammes which is equal to a dose of ·053 gramme per kilo. of body weight. The result of this injection on this animal's temperature is seen in Chart V. on page 167.

The first result of the injection was fever, high on the first day, less on the second day, but present also on the fifth day, after which the temperature became normal. Weakness of the hind legs appeared on the first day; on the second day the right hind leg was more paretic than the left; as also was the case on the third day, when the rabbit was found to have lost 30 grammes in weight. On the fourth day the left hind leg was more paretic than the right; and on the fifth day this condition was increased, the leg being held in slight abduction (*see* Fig. 30, Plate XIV.). From this time onward the animal did not jump except on rare occasions, but advanced each hind leg alternately. Its condition remained practically the same till the 13th day, when it became ill in a manner similar to that described in the previous animals (*see* Figs. 1, 2, and 3, Plate I.). The hind legs, although extended, as is seen in Fig. 31, Plate XIV., were not completely paralysed; flexion was still possible, as seen in Fig. 32. The fore legs were paretic, the breathing was extremely rapid, and the temperature varied between 96·2 and 96·8. The animal died during the night. The post-mortem examination showed the blood coagulated in some parts, but when the uncoagulated blood was removed it was found slow in coagulating. As regards the rest of the post-mortem examination, the results were precisely similar to the condition described in the other animals. Micro-organisms were absent from the body, and there was the same degeneration of the peripheral nerves of the skeletal muscles (*see* Fig. 16, Plate VII.; Figs. 18 and 19, Plate VIII.; and Figs. 21, 22, and 23, Plate IX.), and of the heart, and the same integrity of the central nervous system which has been already fully described.

This result is important, as it shows that in the diphtheria membrane there exists a poison associated with the proteid and precipitable by alcohol, which poison produces on rabbits exactly the same result as the albumoses found in the blood and spleen of diphtheria patients. But it is a poison much more virulent than these albumoses since it acts in much smaller and in single doses. A single small dose of the blood and spleen albumoses will not produce the progressive paresis observed in this case. For example, a dose of 0·123 gramme of diphtheria albumoses from the blood and spleen introduced into a rabbit weighing 1,050 grammes (twice the dose per kilo. body weight administered to the animal now under consideration) produced only moderate fever and nothing else. With a view of testing this further, at the time that this experiment with the extract of diphtheria membrane was in progress, another rabbit was three times injected with blood and spleen albumoses in total amount three times larger than that of diphtheria membrane extract used for the rabbit of Chart V., namely, 0·157 gramme per kilo. body weight in all. As a result, the nerve lesions

Chart V.

Rabbit, weighing 560 grammes, injected (in the marginal vein of left ear) with 0·053 gramme per kilo. body weight of saline dialysed extract of diphtheria membrane. Death on the fourteenth day.



I. Occasion of injection.
a. On this day, weakness of hind legs.
b. „ „ „ more marked, especially of right.
c. „ „ „ „ „ „
d. „ left hind leg more paretic than right.
e. „ distinct palsy of left hind leg which was in slight abduction: weakness of right hind leg.

were as well marked in the animal which had the 0·053 gramme diphtheria membrane extract as in this other which had the 0·157 gramme blood and spleen albumoses, and death occurred in about the same time, viz., 14 days in both animals. Similarly another animal that had nearly twice the dose, namely, 0·083 gramme of blood and spleen albumoses in two successive doses, although it became paralysed recovered completely. The toxic effect of the extract of the diphtheria membrane cannot therefore be ascribed to the mere presence of a small amount of albumoses. There is something in the membrane in addition to the albumoses which is in all probability of a ferment nature.

This dialysed saline extract of diphtheria membrane possesses moreover a different local action to that of the albumoses from the blood or spleen. It may produce simply œdema which will pass off, but in one instance 12 milligrammes injected under the skin of a guinea-pig weighing 710 grammes produced a fever during the first two days of experiment. This fever subsided on the third day and death occurred on the sixth day. Nothing was found post-mortem in the body except at the site of inoculation. Here there was a greyish-yellow, sloughly-looking area containing no pus, and about half-an-inch long; the poison having produced a local necrosis of the tissue.

These results bring my own work into touch with what has already been done on the chemical products of the bacillus diphtheriæ,—the so-called Klebs-Löffler bacillus.

C.—Bacillus Diphtheriæ.

It is sufficient to say here that the diphtheria bacillus was first recognised by Klebs, was first isolated in pure growth by Löffler; and that Roux and Yersin were the first to show that its chemical products when introduced into the circulation of the rabbit produces a paralysis which is progressive and which is, from the description given, of the same nature as that already discussed. Roux and Yersin's results were confirmed by Brieger and Fraenkel. All observers are agreed that the bacillus diphtheriæ is limited to the superficial layers of the membrane and does not distribute itself throughout the body. It is not found in the blood or in any of the organs. Similarly, even when subcutaneously inoculated, although it kills the animal, yet its growth is limited to the site of inoculation. This fact, taken with that established by the brilliant researches of Roux and Yersin, namely, that the products of the bacillus produce paralysis, is a very powerful argument that the bacillus diphtheriæ is the *vera causa*, the living contagion, or, as I prefer to call it, the primary infective agent in diphtheria.

(*a.*) *The Chemical Poison produced by Bacillus Diphtheriæ.*

The chemical poison isolated by Roux and Yersin was of a very virulent nature. They grew the bacillus in veal peptone broth; that is, they used peptone as a food for the organism. Such a culture medium is unsuitable for obtaining the products of a pathogenous organism because it is unlike any liquid medium that exists in the body; moreover the proteid bodies which are produced by pathogenous organisms give the same chemical reactions as the peptic albumoses used in preparing this culture medium. These facts, however, by no means vitiate Roux and Yersin's results. They found that the broth culture when freed from bacilli will kill rabbits, after producing

paralysis chiefly affecting the muscles of the hind legs and of respiration. This poison was precipitated by alcohol, and by phosphate of lime, and could be dried; and they calculated that as little as 0·0004 gramme was capable of killing eight guinea-pigs of 400 grammes each, or two rabbits of three kilos each. Roux and Yersin's conclusions were that this poison was a ferment (*Diastase*), not only from its acting in such small doses which had a prolonged effect on the body lasting over many days, but also from the fact that heating attenuated the poison, while boiling destroyed it. At the end of one of their papers they conclude that "L'infection n'est produite par un microbe envahissant les tissus, mais " par la diffusion dans l'organisme d'une substance toxique, preparée à " la surface d'une muqueuse, pour ainsi dire en dehors du corps."

Brieger and Fraenkel repeated Roux and Yersin's experiments, and confirmed them. They attempted to determine accurately the chemistry of the diphtheria product, which they called "toxalbumen," but their chemical analyses and reactions are quite vitiated by the fact that they had peptone in their culture medium. They found, like Roux and Yersin, that the proteid or mixture of proteid precipitated from the culture medium by alcohol, acted in very small doses, such as 5 to 20 milligrammes, when injected into the circulation of an animal; but they made the hasty conclusion that a poison like this diphtheria product existed in all infectious diseases. In fact, they carried the subject no farther than Roux and Yersin had done.

In my own experiments, I have obtained the products of the bacillus diphtheriæ by using as a culture medium beef-broth containing 1 to 2 per cent. alkali-albumin, but no peptone. After 22 to 32 days at 38° C. it is found that the bacillus has transformed the alkali-albumin into albumoses, which give the reactions of proto- and deutero-albumose. Small quantities of the organic acid were also obtained.

(*b.*) *Physiological Action of the Albumoses produced in culture by Bacillus Diphtheriæ.*

A *single large dose* of these albumoses, equal to 0·115 gramme per kilo of body weight of the rabbit experimented on, produced on the first day a weakness of the hind limbs, and to a less extent of the whole body; this passed off, but the rabbit lost weight for 10 days or more. It afterwards regained its weight, and when killed on the 100th day, it was fat and well-nourished. The microscopical examination revealed the same changes as have been described as following the injection of a single dose of the albumoses found in the tissues of patients dead of diphtheria. The heart showed advanced fatty degeneration, and there was well-marked degeneration of the phrenic nerve and of the nerve to the vastus muscle, the only two nerves examined.

Multiple Doses.—A rabbit received intravenously three doses, equal to 0·111 gramme per kilo. of body weight. There was a well-marked fever, which subsided after the last dose. But beyond this there were no symptoms: no paralysis, no diarrhœa, and no loss of weight. The tendon reflexes were also normal. The animal was killed on the 30th day. The post-mortem showed well-marked fatty degeneration of the heart; and a similar, although less marked, change in the diaphragm and triceps brachii, while the parts of the vastus internus, semimembranosus, semitendinosus, and gastrocnemius examined, were normal. The phrenic nerve, and the nerves to the muscles mentioned (with the exception of the nerve to the semitendinosus), showed degeneration in a moderate degree. The left phrenic, *e.g.*, in the middle of the thorax was

normal, but one of the branches on the diaphragm was degenerated. One or more branches of each of the other motor nerves mentioned was found degenerated, but there were only a few ruptured axis cylinders, and no well-marked Wallerian degeneration; which accounts for the fact that no paralysis was observed during life.

A larger dose than this, however, produced the same symptoms which have been described as following the intravenous injection of the albumoses obtained from the tissues of patients dead of diphtheria. Thus a rabbit, weighing 1,065 grammes, received three doses on successive days of the albumoses of the bacillus diphtheriæ, equal to a total dose of 0·169 gramme per kilo. of body weight. After the first two doses there was high fever; but after the third a depression of temperature occurred, which lasted two days. Severe watery diarrhœa set in and lasted until the ninth day. The wasting was very rapid, and on the twelfth day the animal weighed only 800 grammes, having lost a quarter of its original weight; after the twelfth day, however, it rapidly regained weight, scaling on the nineteenth day 1,000 grammes. There was a general weakness of the muscles on the fourth day, but no definite paresis until the eleventh or twelfth day, when the hind legs were distinctly affected, as the animal advanced one leg after the other, like a cat. The paresis continued for some weeks, but the animal gradually regained power in its limbs; its weight rapidly increased, until in 35 days it weighed 1,255 grammes. The tendon reflexes were present and normal up to the ninth day, when they began to diminish until the seventeenth day; the left reflex on this date being more marked than the right.

Conclusions as to Diphtheria.

From the facts under consideration it is clear that—

1. The bacillus diphtheriæ forms in diphtheria membrane and in culture media, proteid products of the same chemical nature as those found in the bodies of patients dead of diphtheria, viz., albumoses and an organic acid.
2. The albumoses formed by the bacillus diphtheriæ in artificial cultivation, have in single and multiple doses the same physiological action as those found in the human body after death by diphtheria. This action is the production of fever, of diarrhœa, of loss of body weight, and of a progressive paresis of the muscles resulting from a degeneration of the peripheral nerves.
3. The bacillus diphtheriæ is, therefore, the primary infective agent in diphtheria.
4. The diphtheria bacillus liberates in the membrane a ferment which when absorbed digests the proteids of the body, forming albumoses and an organic acid.
5. These digested products, which are the agents in producing death, cause the fever and the depression, and as well the paralysis which follows diphtheria.

It is clear from the cases of diphtheria which have been described that the diphtheria products found in the body do not all come direct from the membrane. In case 1, for example, only small flecks of membrane were found in the larynx, and yet in the dead body a large

quantity of the diphtheria products were discovered. The large amount of albumoses and organic acid found in the spleen also shows that something more than absorption of albumoses is going on. There is no reason to suppose that these albumoses merely accumulate in the spleen, while their specific physiological action shows that they are foreign to the organism. It is more probable that the ferment absorbed from the membrane digests the more or less stagnating proteids in that organ; (we know, indeed, that the spleen contains in proportionately larger quantity than the blood of bodies formed from proteids, such as uric acid, xanthin, &c.), and in this view the relation of Roux and Yersin's poison to those I have described as present in the bodies of diphtheria patients becomes easy of comprehension.

It is possible now, therefore, to formulate in tabular fashion the chemical pathology of diphtheria, contrasting it with that of anthrax, and bringing both diphtheria and anthrax digestion into line with the processes of the peptic and tryptic ferments. Thus:—

Digestion Process.	Primary Agent or Primary Infective Agent.	Secondary Agent, or Ferment.	Digestive Products.
Peptic	Living cell	Pepsin	Syntonin. Hetero-albumose. Proto-albumose. Deutero-albumose. Peptone.
Tryptic	Living cell	Trypsin	Globulin-like body. Tryptone (peptone). Leucin, tyrosin. A bitter body.
Anthrax	Bacillus anthracis	- -	Hetero-albumose. Proto-albumose. Deutero-albumose. Peptone. Leucin, tyrosin. Alkaloid (base).
Diphtheria	Bacillus diphtheriæ	Diphtheria ferment (Roux and Yersin's poison); in membrane.	Hetero-albumose } In membrane. Proto-albumose } In body. Deutero albumose } In body. Organic acid } In body.

II.—INFECTIVE ENDOCARDITIS.

The specific action of the diphtheria products is brought into greater prominence when it is contrasted in parallel experiments with the chemical bodies found in anthrax and in infective endocarditis. A case of infective endocarditis which I had opportunity of studying, was under the care of Dr. Cayley, at the Middlesex Hospital, and I, as pathologist to that hospital, made the post-mortem examination.

The patient was a young unmarried woman, aged 21 years. Her illness began eight weeks before death, with pain in the left breast, and was, during her six weeks' stay in the hospital, characterised by wasting and intermittent fever. Her temperature rose to 103° F. or 104° F. every day, and only once did shivering occur. The cardiac signs were those of double mitral disease. Four weeks before death the right brachial artery became plugged by an embolus; and three weeks before death, the same accident happened to the left femoral artery. Albuminuria occurred four weeks before death.

At the post-mortem examination, 12 hours after death, there was found chronic disease of the mitral valve, with fungating vegetations spreading over the endocardium of the left auricle and ulcerated on their surface.

The blood was imperfectly coagulated, and was lakey in colour. There was a recent embolus in the left middle cerebral artery, and older emboli (surrounded by organising thrombi) in the right brachial and left femoral arteries. At the origin of the superior mesenteric artery there was a softening embolus. The right kidney showed two scars of old infarcts, and there were two caseated infarcts in the spleen. The spleen was greatly enlarged, dark and congested. The liver was fatty, the kidneys fibro-fatty, and the lungs œdematous.

This was then a case of infective endocarditis without associated abscesses or pyæmia.

The mitral valve was examined microscopically and the blood and spleen chemically, while cultivations were made from the blood and from the vegetations on the mitral valve. Microscopically this valve showed the fibrous thickening of chronic disease, with recent vegetations capped by fibrin. Fig. 33, Plate XV., shows a section of the free edge of the vegetations. The fibrils of the fibrin are seen capping the thickened connective tissue containing collections of round cells. Along the free edge of the fibrin is a fringe of micrococci, very thick and invading the fibrin. Outlying clusters of the cocci are also seen, and in some parts the micro-organisms are seen in groups in the tissue of the valve itself.

In this case then the micro-organism had as its culture medium the fibrin capping the vegetations.

Bacteriological Examination.—No micro-organisms were found by making cultivations of the blood of the right ventricle. From the vegetations on the mitral valve, a pure cultivation was at once obtained of cocci with the same microscopical appearance as those seen in the valves. Only one culture out of the five made showed any contamination: the other four afforded growth of the coccus alone.

Without going further into the bacteriological procedure, this organism may be described as growing on agar in bluish white opaque circular colonies, and on gelatine in a similar manner but rapidly liquefying the medium. Microscopically it is a staphylococcus, forming clusters and not chains. (*See* Fig. 34, Plate XV.)

Pathological Action of the Staphylococcus of Endocarditis.—The coccus in question did not produce pus when introduced under the skin of a guinea-pig or into the circulation of a rabbit. On subcutaneous inoculation in the guinea-pig it produced a febrile disorder lasting over 11 weeks, accompanied by extreme wasting and ending in death. When injected into the circulation of rabbits, only a slight illness resulted from which the animals recovered. When killed, no micro-organisms were discovered in their blood.

The pathological effects of this micro-organism have, however, yet to be completely worked out. I contented myself as a commencement with determining what sort of illness it produced in animals, and whether it formed abscesses.

Each case of infective endocarditis must be studied by itself, for the disease is by no means an entity. Some cases of ulcerated cardiac vegetations occur as part of a pyæmia proceeding from pelvic or other abscesses, where the primary infective agent appears to be the staphylococcus or streptococcus pyogenes. In others, again, no primary pus-focus is found; but there are multiple abscesses due to infective emboli from the ulcerated valves. Other organisms, such as Friedländer's pneumococcus may also possibly play a part in this disease.

In the particular case under consideration, however, there was only one micro-organism, and that one not a pus-former.

Chemical Examination of the Tissues in Endocarditis.—A chemical examination was made in this case of the blood and spleen by the methods that I have already described. The result showed that the same two classes of products were present in the blood and spleen as had been found in anthrax and diphtheria, viz., digested proteids or albumoses, and a non-proteid product. The latter when first separated and purified was strongly acid.

The albumoses were proto- and deutero-albumose (chiefly the latter), indistinguishable by chemical reactions from the similar bodies I have already discussed. The final product is separated by alcohol: it is precipitated by ether and is insoluble in chloroform. Separated in this state it is an amorphous, yellowish brown body, with a strongly acid reaction.

The amount of the products obtained is seen in the following table:—

—	Albumoses.	Alcoholic Extract.
From blood of endocarditis case -	0·236 gramme	Trace.
From spleen „ „	6·705 „	1·29 gramme.
	6·941 „	

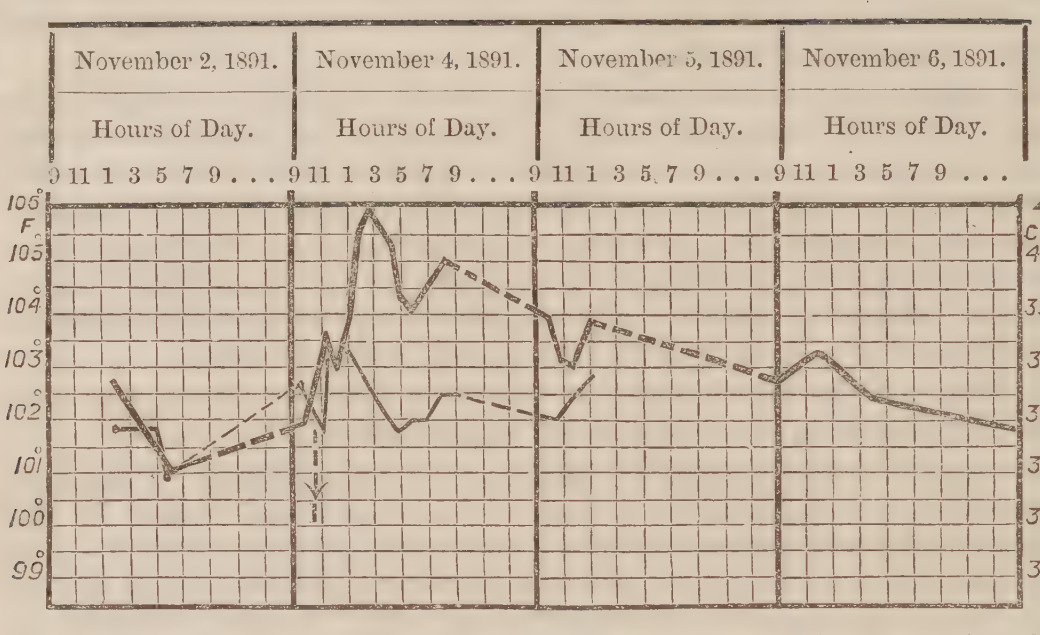
The large amount of albumoses and of alcoholic extract obtained from the spleen is remarkable. Here again, as in diphtheria and in anthrax, the spleen is the repository and manufactory of the chemical poison.

Physiological Action of the Albumoses of Endocarditis.—The physiological action of the albumoses was, while the experiments on diphtheria were progressing, tested side by side with that of anthrax albumoses. So the animals of all three series could be compared.

The albumoses of infective endocarditis are producers of fever, and retard the coagulation of the blood. The fever produced can be well seen in the following temperature charts, which show the effect produced by the albumoses of infective endocarditis and of anthrax injected in the same dose into rabbits.

Chart VI. shows the effect of the intravenous injection of a dose of 0·122 gramme per kilo of body weight. With the anthrax albumoses, the rise of temperature is great, and lasts for three days. With the infective endocarditis albumoses the fever produced is much less marked.

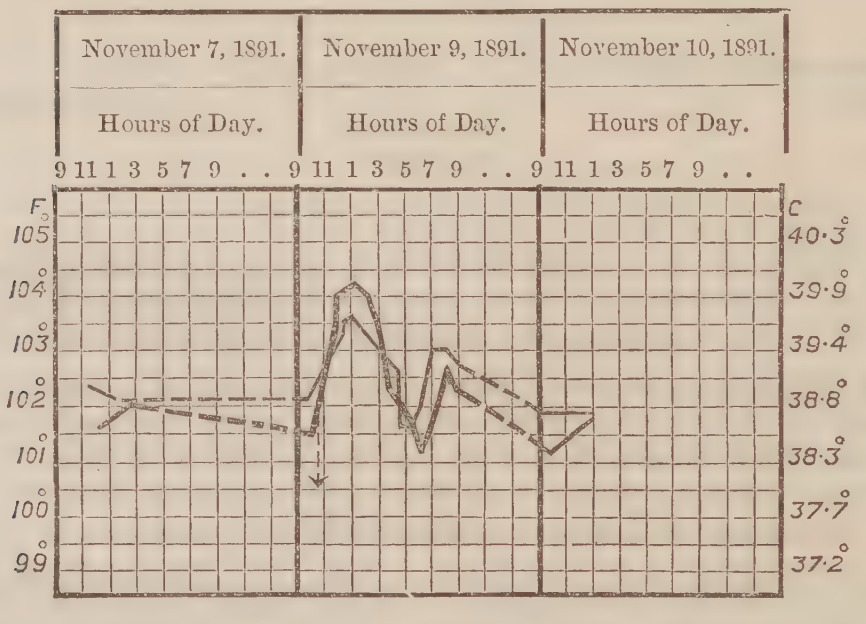
Chart VI.



I. Intravenous injection of 0·122 gramme (albumoses of the one or the other sort) per kilo. body weight of experimental rabbit.
Thick line represents temperature after injection of anthrax albumoses.
Thin line „ „ „ „ albumoses from infective endocarditis.

With a larger dose (0·2 gramme per kilo. of body weight) the fever in the case of the anthrax albumoses is not so well-marked, while in the case of the albumoses of infective endocarditis it is more marked than with the smaller dose.

Chart VII.

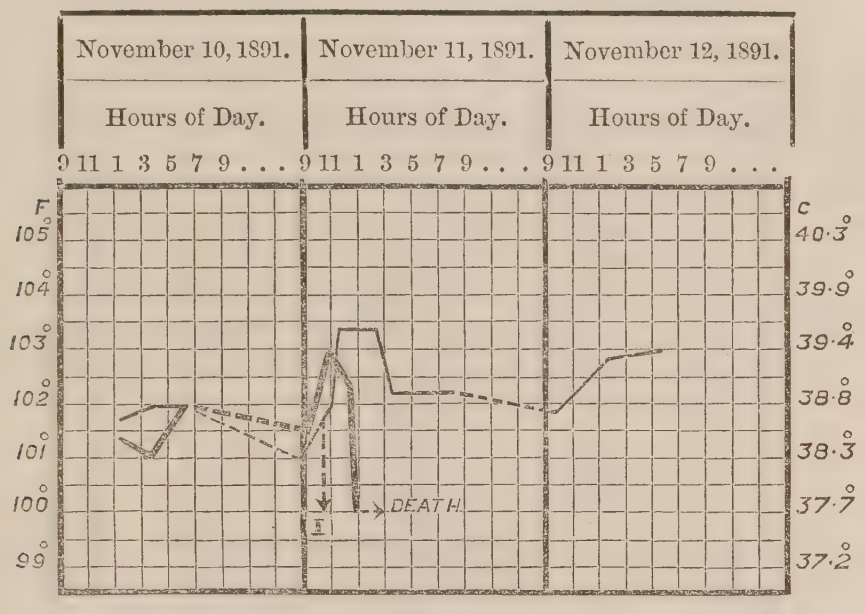


I. Intravenous injection of 0·2 gramme (albumoses of the one or the other sort) per kilo. body weight of experimental rabbit.
Thick line represents temperature after injection of anthrax albumoses.
Thin line „ „ „ „ albumoses of infective endocarditis.

With a still larger dose (0·3 gramme) the anthrax albumoses cause only a slight rise of temperature, succeeded by a fall and death in two

hours, while the albumoses of infective endocarditis cause a moderate rise of temperature, which is continued for two days.

Chart VIII.



I. Intravenous injection of 0·3 gramme (albumoses of the one or the other sort) per kilo. body weight of experimental rabbit.
Thick line represents temperature after injection of anthrax albumoses.
Thin line „ „ „ „ albumoses of infective endocarditis.

The anthrax albumoses, therefore, are much more toxic than those from infective endocarditis. The fever produced by them is well marked with a small dose, but with larger doses it is less, and with a lethal dose it is very slight indeed.

In the experiments just described there was no paralysis produced, but wasting was observed in some of the animals. The following table gives the gain or loss in weight of thirteen experimental rabbits; six of them inoculated with anthrax albumoses, other seven with the albumoses of infective endocarditis.

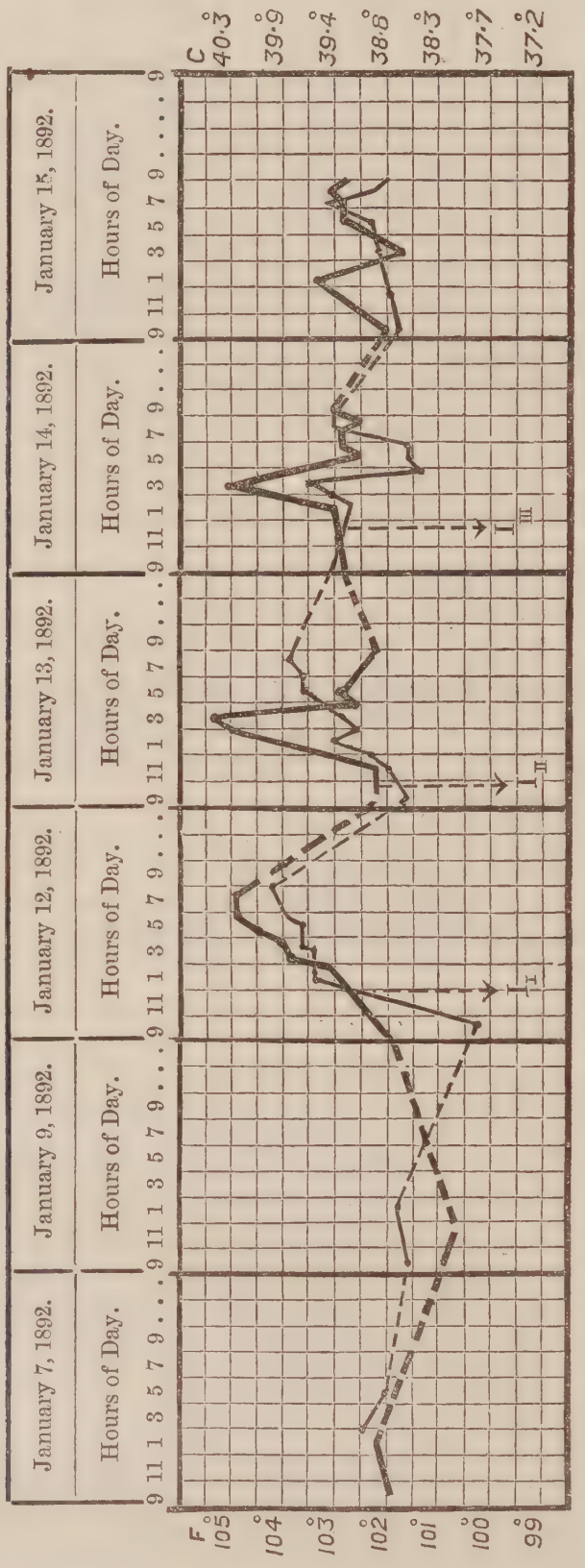
Dose per kilo of Body Weight of Rabbit.	Anthrax Albumoses.			Albumoses of Infective Endocarditis.		
	Gain.	Loss.	Weighed after Inoculation.	Gain.	Loss.	Weighed after Inoculation.
Grammes.	G.	G.		G.	G.	
0·122	200	—	28 days	—	90	16 days.
	—	—	—	30	—	28 „
0·2	—	530	12 days	100	—	11 „
	—	80	102 „	652	—	102 „
0·3	Death in 2 hours			70	—	10 „
0·153 (in three doses)	—	—	—	83	—	100 „
	—	—	—	210	—	4 „
0·122 (in three doses)	—	130	4 days	—	—	—
	—	1,020	42 „	—	—	—

These figures show that the anthrax albumoses produce a greater effect on nutrition than those of infective endocarditis.

When multiple doses of these products are given, fever is produced, but no paralysis, contrasting greatly with diphtheria products. Chart IX. shows the effect on the temperature of three doses of anthrax albumoses

on successive days = 0·122 gramme per kilo. of body weight: and of the albumoses of infective endocarditis also in three doses = 0·153 gramme per kilo. There is a rise of temperature each day following the injection, which was continued for one day after the last inoculation.

CHART IX.



I I$_{II}$ I$_{III}$. Occasions of injection of albumoses.

Thick line: Temperature following injection of three doses of anthrax albumoses (each 0·04 gramme per kilo. of body weight) on three successive days. Total dose per kilo. 0·122 gramme.
Thin line: Temperature following injection of three doses of albumoses from infective endocarditis (each 0·051 per kilo.) on three successive days. Total dose per kilo. 0·153 gramme.
The injections were made intravenously in rabbits.

The anthrax animal died in 42 days, having lost two-fifths of its body weight, while the ulcerative endocarditis animal showed no loss of weight, and was killed on the fifty-third day. This last was an adult rabbit; a young animal injected with the same dose of endocarditis albumoses died after the last injection on the third day.

Post-mortem Examination of Experimental Animals.—The post-mortem examination of the animals that died or were killed, showed the absence of any pathogenous micro-organisms. A microscopical examination of the phrenic nerves and of the motor nerves was made, and revealed no morbid condition; no nerve degeneration, such as was observed as the result of injection of the diphtheria products. The contrast with diphtheria is therefore well marked. Fatty degeneration of the heart was found in some of the animals, especially those which had been inoculated with the anthrax albumoses, and in the animal which had the largest single dose of the albumoses from infective endocarditis.

This fact helps to explain the fatty degeneration of the heart following the injection of the diphtheria products. Occurring as it does also in the animals inoculated with anthrax and ulcerative endocarditis albumoses, it tends to show that the fatty degeneration is due to an effect on the nutrition of the heart by the albumoses circulating in the blood stream.

General Considerations.

Having now set out the facts in the chemical pathology of these infective disorders, diphtheria and endocarditis, it is necessary to consider generally their bearing.

In summing up the effect on the body of the introduction into it or upon it of a primary infective agent, the symptoms may be referred to two causes, (1) Mechanical, (2) Chemical. Mechanical effects are illustrated by the fact that the infective agent may, as in diphtheria, produce a membrane which spreading down the air passages endangers life. The effect of this mechanical obstruction, which is to some extent relieved by intubation or by tracheotomy, is well recognised as a danger in diphtheria. Another example of mechanical effect is seen in infective endocarditis, in which not only do the fungating vegetations interfere with the proper action of the valves of the heart, but the emboli broken off from them, by plugging large vessels, cut off or diminish the blood supply to one or another part and so lead to grave results. Although such mechanical effects may be looked upon as merely pathological accidents, their consequences have to be considered in dealing with the pathology of these diseases. They sink, however, into comparative insignificance when the rôle of the chemical products of the primary infective agent is elucidated.

What has been made clear to me during the course of this research is that these chemical products are specific in their action. That inasmuch as the bacillus anthracis is separable from other pathogenous micro-organisms as producing a definite disease, anthrax; so the chemical products of the bacillus are separable to a certain extent chemically, and to a greater extent physiologically, from those formed by other pathogenous micro-organisms. Similarly with diphtheria, the bacillus diphtheriæ affords products differing in their physiological action from those found in anthrax and from those found in infective endocarditis. The specific primary infective agent manufactures alike in anthrax and in diphtheria, therefore, specific chemical products by means of which it acts.

Hence it is evident that we have, in addition to that purely bacteriological one which consists in the study of the primary infective agent, another and a new basis for the study of infective disorders. Compliance with the following, now well-known, bacteriological conditions has been accepted as necessary for proof that a particular micro-organism is the cause of a disease:—(1) it must be found always associated with the disease, (2) it must be separable from the diseased tissues in pure

culture, (3) it must, when injected into susceptible animals, reproduce in them the original disease, (4) it must be recoverable from this experimentally produced disease.

To these must now be added another condition, viz., that definite chemical poisons must be obtainable from the tissues in the natural disease, and that products with a similar physiological action must be obtainable through the life processes of the primary infective agent when it is grown outside the animal body. Compliance with this latter condition is indeed called for if there is to be progress in pathology, because in some instances, as in cholera and leprosy, lower animals susceptible to the disease are not forthcoming. For instance, if it can be definitely proved that certain chemical poisons with a specific (cholera) action are present in the bodies or evacuations of cholera patients, and if the vibrio choleræ asiaticæ produces in artificial media the same products, then we must look upon this micro-organism as the cause of the cholera disease.

It is possible, too, that in some infective disorders, such as measles, scarlet fever, and small-pox, in which the primary infective agent is as yet unknown, a chemical examination of the tissues of persons dead of these diseases on the lines now laid down, may aid in the discovery, in each instance, of the living contagion.

Further, in this way it will be possible to decide whether such a disease as has been described as membranous croup of the larynx really exists. There is not sufficient evidence at present of the existence of any disease other than diphtheria which can produce a false membrane in the larynx. The data which have been brought forward in support of membranous croup as distinct from diphtheria are but scanty; and now that it is known definitely that diphtheria is a disease caused by the bacillus diphtheriæ, and that the chemical substances found in this disease are readily recognisable by the fact of their producing a definite nerve lesion, it is open to any observer who still maintains the existence of membranous croup, to separate in such cases the chemical substances from the "croupous" membrane, or from the body after death, and to decide their nature.

In a word, it is necessary now to insist that in studying the chemical pathology of an infective disorder it is not sufficient to investigate the chemical products in artificial media of the primary infective agent; a chemical examination of the tissues of persons dead of the disorder must also be performed. How important this is is sufficiently shown by a particular fact which has been brought out in these experiments, viz., the pathological rôle of the spleen.

Rôle of the Spleen.—The spleen is an organ with an obscure physiology, and with a pathology still more obscure. Anyone who has tried to understand what has happened to a spleen of an animal dead of infectious disease must have been struck with the utter hopelessness of coming to any definite conclusion regarding that organ from a merely physical examination. From the physiological point of view it is known to undergo certain mechanical changes which can only be of slight import, and (besides being a birthplace for white blood cells) to contain in comparatively large amount the crystalline products of the breaking up of proteids such as uric acid, &c. The chief point about the organ, however, from a pathological point of view is the circumstance that the blood flows through the walls of its vessels into spaces. Thus we have in the spleen a more or less stagnating fluid, the proteids of which can be digested either by micro-organisms or by ferments. In anthrax and in infective endocarditis this organ is greatly enlarged; in diphtheria it is usually normal in size. In all three cases it is from the proteids of

the spleen that the specific poisonous products are mainly formed; these serve as the "food," so to speak, of the infective agents, primary or secondary.

Food for the Infective Agents.—Besides the spleen there are other parts of the body in which the primary infective agent finds suitable pabulum for its processes. Thus pathological effusions, whether already present in the body or formed there by the primary infective agent, are suitable pabulum for this agent. These effusions, speaking generally, may be considered as slightly alkaline solutions of proteids which are outside the active metabolism of the body, *i.e.*, these proteids are not contained in a living fluid like the blood. The bacillus anthracis, for example, when injected under the skin of an animal, itself causes effusion by means of its products, and thus provides its own culture medium. The interstitial fluids too of the tissues of the body, containing as they do the amount of proteid, sodium chloride, and phosphates necessary for the growth of the primary infective agent, probably serve also as culture media.

Lastly, in diphtheria and in infective endocarditis, fibrin serves as the medium in which the micro-organism flourishes. In diphtheria the false membrane is composed of fibrin, which, as I have shown, is in a state of digestion, and the exudation of this fibrin is no doubt one of the earliest results of the growth of the bacillus diphtheriæ.

And in the case of infective endocarditis the nidus of the micro-organism is the fibrin capping the vegetations.

Without a suitable medium the primary infective agent cannot thrive, and cannot go on to manufacture its poisonous products.

Products formed by the primary Infective Agent.—I have attempted to make clear the fact that in the infective disorders under consideration the primary infective agent or living contagion produces its effect in man by means of its specific chemical products; and that it forms these from the proteids of the body with or without the intervention of a ferment. It may be that in all cases the chemical substances which are especially poisonous are produced by means of an unorganised ferment excreted by the primary infective agent; but the point that concerns us is that in only one of the diseases examined, viz., diphtheria, is there any evidence to show that this ferment plays a direct and important pathological rôle. In this disease, in which the bacillus diphtheriæ is limited to the superficial parts of the membrane and does not diffuse itself throughout the body, it has been seen that there is something excreted by the bacillus and then absorbed into the system, in the tissues of which were afterwards found certain digested products. This excretion, so to speak, of the bacillus has been looked upon as a ferment, and is regarded as the "secondary infective agent." In anthrax and in infective endocarditis, on the other hand, the primary infective agent is dispersed in the body itself, and there is no evidence that a ferment necessarily plays any direct part in the causation of the symptoms of the disease. I very much suspect that in tetanus, a disease which resembles diphtheria in the fact that the primary infective agent is limited to the site of inoculation, that a ferment or excretion of the bacillus acts as a secondary and principal infective agent; but this is as yet quite undecided.

The secondary infective agent, or *ferment*, now in question cannot be expressed in any chemical terms: only in terms of what it can accomplish, either (1) of its physiological action or (2) of its capacity for forming from proteids chemical bodies which resemble it in physiological action. This secondary infective agent is one possessing properties which, like those of unorganised ferments, are usually expressed by the

term "vital"; it is, as it were, one of the "vital" properties of the living cell cast off in a form which is unorganised.

The products whether of the primary or of secondary infective agents are chemical bodies belonging, as I have shown, to two groups—proteid and non-proteid. The proteids belong to the class of digested proteids or albumoses and peptone; the non-proteids are final products from the digested proteids, and are therefore analogous to the leucin and tyrosin of pancreatic digestion.

The organic constituents of the animal body consist of proteids, carbo-hydrate, fats and certain so-called extractives which like urea, uric acid, &c., are nitrogenous and the result of proteid metabolism. There is no evidence at present that pathogenous micro-organisms can form from fats and carbohydrates poisonous bodies: they may break them up, but the chemical bodies produced have but little physiological action. The proteids, on the other hand, are substances which from their enormous molecule and from the presence of nitrogen are capable of being split up into poisonous bodies.

The chemical difficulty with proteids is that there is no knowledge of the size of their molecule and, what is of great importance, of their molecular construction. Their percentage composition gives no idea of the size of their molecule, and the only idea we have of the molecular constitution of a proteid is from a study of the chemical constitution of the nitrogenous bodies resulting from its destruction.

It is not, therefore, surprising that with regard to the first class of poisonous products under consideration, viz., the albumoses, no very definite chemical knowledge is forthcoming; or that, as I have stated, all the albumoses I have been describing give the same chemical reactions. An ultimate analysis to determine the percentage composition is of but little value in the case, as it is the molecular constitution that we wish to know. We have, therefore, to express the albumoses in terms of their physiological action, and to be content with demonstrating that the diphtheria albumoses differ from peptic albumoses and from those found in anthrax and in infective endocarditis, in producing a paralysis consequent on a nerve degeneration; and that the anthrax albumoses are more poisonous than those of infective endocarditis.

The Chemistry of the Final Products.—The anthrax base, as also the organic acid in diphtheria, will probably on further investigation yield very fruitful and definite results. Such an investigation is, however, perhaps one of the most difficult in organic chemistry. Indeed the physiological action of these substances is of more importance than their chemistry; but as they are factors in disease, and in some diseases the chief factors, the more complete our knowledge of them the more likely will the means be found to combat them. In anthrax, it is the final product, the alkaloid, which is the cause of death; the albumoses play a very subsidiary part in the production of the fatal result. In diphtheria, on the other hand, the albumoses play the more important rôle, while the organic acid has only an insignificant action. There may, indeed, be other diseases in some of which the albumoses play the chief pathological rôle, in others the final product, whether base or acid.

Comparison with other Poisons.—These poisons found in infective diseases do not stand alone; they are related to others found both in the vegetable and animal kingdoms. Albumoses (which I have called phytalbumoses) are widely spread in vegetable tissues; they exist in the seeds and probably other parts of plants. Alkaloids or bases are also obtained from plants, and it appears to me a very promising field

of research to determine whether the vegetable alkaloids are associated with digested proteids; whether, in fact, the vegetable cell produces, like the bacillus anthracis, two classes of products, albumoses and a base. This is, however, a question for the vegetable physiologist.

In some seeds (Abrus precatorius and Ricinus communis) there are proteids which have a distinct and powerful poisonous action. In the jequirity seed, *e.g.*, there are, as I have elsewhere shown, two poisonous proteids, a globulin and an albumose, both of which produce in very small doses a general disease, two of the features of which are the production of ecchymoses and the occurrence of sanguineous diarrhœa. The jequirity proteids resemble in many respects those of snake venom and are like the albumoses of diphtheria and of infective endocarditis in producing a watery diarrhœa. I think indeed that the jequirity poison more closely resembles the secondary infective agent in diphtheria than any other poison that I know; it partakes too of the nature of a ferment in its ready destruction by heat. Whether it produces a peripheral nerve degeneration or not I do not yet know.

Effect on the Blood and on Nutrition.—One of the effects common to many of these proteid poisons is their power of preventing or hindering coagulation of the blood. This we have seen to be the case with the diphtheria albumoses, the effect of which in this respect is well marked and lasts a long time after they have been injected into the circulation. The albumoses of infective endocarditis also have this power; and it is also possessed by the albumoses of peptic digestion, by the jequirity poison, and by many kinds of snake venom.

This action shows that these poisons have a profound effect on the blood, and may account for the grave defects in nutrition which have already been described. The animals poisoned with the diphtheria or anthrax albumoses, go on wasting after the fever has subsided, the loss of weight being greatest in animals poisoned by diphtheria products, and being proportional to the dose of the poison given. In connexion with this wasting, there is the fatty degeneration of the cardiac muscle which has been shown in these experiments to follow the injection of not only the diphtheria products, but also, although to a less extent, the albumoses of anthrax and of infective endocarditis. There is no definite evidence that cardiac degeneration is directly dependent on a nerve lesion either central or peripheral; and the fact that it is well marked after the injection of the anthrax albumoses which produce no degeneration in the nervous system, points, in my opinion, to the conclusion that it is to the change in the blood which these poisons bring about that we must ascribe the fatty change. This fatty degeneration may, indeed, only be the final result of the poisons being special cardiac poisons; the skeletal muscles indeed do not become fatty like the heart, unless there be nerve degeneration as in diphtheria.

Effect on the Body Temperature.—From the experiments which have been described it is clear that the proteid products (albumoses) of the primary infective agents have a profound effect on the body temperature. Ott and Calmar first showed that ordinary peptic albumoses cause a rise of body temperature, and several observers have worked out the effect of injecting into animals "septic material" freed from micro-organisms. These experiments were performed at a time when the chemical characteristics of the products of pathogenous micro-organisms were unknown. The time has now passed for using impure material for physiological experiment.

The most typical effect on the body temperature is seen in the case of the anthrax albumoses. A medium dose injected produces a high

body temperature, and a continuation of the fever for some days; a larger dose produces a less pronounced rise, and a shorter duration of the fever period, while a still larger dose causes only a slight rise of temperature, followed by a sudden fall, ending in death. (*See* Charts VI., VII., and VIII.) The albumoses of infective endocarditis also produce well-marked fever; and with a certain dose a fall of temperature, which ends in death. The albumoses of diphtheria and of tetanus must be classed together. They are not such active fever-producers as those just considered. The diphtheria albumoses do produce fever, and fever lasting some time; but a much smaller dose is required to do this than in the case of anthrax albumoses; and with tetanus albumoses, the depression of temperature following the injection is well marked. The degree of fever is dependent on the dose of the albumose given.

Effect on the Nervous System.—Many of these poisons select the nervous system for their action. One of the features of the action of albumoses is the production of coma, and in anthrax this coma is due to the action of the base or alkaloid. Coma is also a feature of jequirity and of snake poisoning. The final action of the albumoses in diphtheria is the production of coma, but their special action is to produce a paralysis dependent on nerve degeneration. It is quite possible that other products in other diseases will be found to produce peripheral palsy.

The effect on the respiration which is observed in snake poisoning is ascribed to the action of the poison on the central nervous system, and when working at jequirity I came to the conclusion that its action on the respiration was also central. In diphtheria, however, where there is peripheral degeneration of the phrenic nerve, it is difficult to say how far the respiratory difficulties are dependent on the peripheral degeneration, and how far they are due to a direct effect on the centres of respiration. Apart from mechanical obstruction, dyspnœa is one of the features of diphtheria in its acute stage, and it is possible that it may be due to a direct effect of the poison on the central nervous system. But here, again, it is difficult to exclude a peripheral action on the phrenics, for, as I have shown, the diphtheria products are special nerve poisons, and they cause degeneration of the nerves even during the short course of the acute disease.

Question of Immunity to be obtained by Injection of the Chemical Products.—There is one question which I have left untouched, viz., that of the conferring of immunity against a disease by the means of its chemical products. This is, of course, an important question. We have been considering the chemical products of an infective disorder, or of the primary infective agent, as specific in reproducing when injected into animals the symptoms of the disease. But it is evident that if the chemical products are capable of protecting an animal against the invasion of the primary infective agent, that this action must be essentially a specific one. For example, we could not suppose that the chemical products of anthrax would protect against diphtheria, or those of diphtheria against anthrax, but that only the products of anthrax could protect against the invasion of the bacillus anthracis. I wish to speak of the matter only in a general manner. I am not at all sure that in all diseases there is this protection.

In discussing the chemical products, whether formed by the primary infective agent outside the body or in the tissues by the natural disease, I have not mentioned any substances except those that are effective in producing the symptoms of the disease. There are some who have considered that the total chemical products in a given disease, may consist

of a "vaccine" and a "toxine." There is not the slightest evidence in support of this view. There is no evidence of the existence of any chemical "vaccine" separable from the chemical "toxine," and I need, perhaps, hardly point out that such a "vaccine" has never been isolated. It is a term that was invented to explain phenomena which are not properly understood. There is also no evidence that there is any particular chemical substance produced in artificial media which stops the growth of a pathogeneous micro-organism. When grown in a flask, it will not develop indefinitely; and it stops multiplying not because there is an anti-toxin formed, but because it is choked by its own chemical products in the same manner as peptic or tryptic digestion may be inhibited by the accumulation of the digested products.

Addendum to Dr. Sidney Martin's Report: Cases of Diphtheria dealt with therein.

Case 1.—*Laryngeal Diphtheria. Tracheotomy.*

Male, aged 12 months. Admitted to the Middlesex Hospital, under the care of Dr. Cayley, February 25th, 1891. Died February 25th.

Duration of illness.—February 20–February 25: 6 days.

History.—On February 20th this child developed a bad cough, with a "whoop" in the evening; recurrence of "whoop" on the 21st. The patient gradually became worse and died in dyspnœa soon after admission into the hospital, tracheotomy having been performed at once.

Post-mortem examination.—3¼ hours after death.

Body well developed and well nourished. Rigidity absent. No œdema.

Larynx.—Recent tracheotomy wound. A few small flakes on surface of mucous membrane, with some small excoriations. *Microscopically*, these flakes had the structure of diphtheritic membrane; fibrils of fibrin with bacilli at the surface; no micrococci.

Pharynx and fauces normal.

Lungs.—Pleuræ normal. Few patches of collapse in right middle lobe and at left base. Lungs and bronchi otherwise normal.

Heart normal. *Blood*, fluid, dark.

Peritoneum, and all *abdominal organs*, normal to naked eye.

Remarks.—This was a case of laryngeal diphtheria, with so few signs post-mortem that no definite diagnosis could be made until the mucous membrane was examined microscopically. The dyspnœa *may* have been partly due to spasm of the glottis, but more probably to the diphtheritic poison itself, a large quantity of which was found in the blood, spleen, and kidneys. With such thin diphtheritic membrane as existed in this case, the absorption of the ferment into the blood was facilitated.

Case 2.—*Nasal, Pharyngeal, and Laryngeal Diphtheria. Tracheotomy.*

Female, aged 5 years. Admitted to the Middlesex Hospital, under the care of Dr. Douglas Powell, April 19th, 1891. Died May 1st.

Duration of illness.—8 days: April 25th–May 1st.

History.—"Croup" two years ago. Measles 12 months ago, followed by whooping-cough. Discharge from ear 13 days before death.

Present illness began with a bad cold, a croupy cough developing with dyspnœa.

During stay in hospital there was nasal discharge, and a large quantity of membrane in the pharynx; great dyspnœa, partly relieved by tracheotomy two days before death. The temperature varied between 100° and 103° F.

Post-mortem examination.—Three hours after death.

Body well developed and well nourished. Rigidity absent. No œdema. Posterior part of nose, the fauces, pharynx, and larynx covered with thick yellow adherent false membrane, extending down trachea to larger bronchi. *Microscopically*, numerous colonies of B. diphtheriæ on surface of membrane. Recent tracheotomy.

Lungs.—Patches of collapse and emphysema. No broncho-pneumonia.

Heart normal. *Liver and spleen* congested. *Kidneys* pale.

Blood dark, fluid; coagulating slowly.

Remarks.—This case is the ordinary type of severe diphtheria passing down the trachea and bronchi, necessitating tracheotomy, which relieves for a time, although the patient ultimately dies in dyspnœa.

Case 3.—Tonsillar Diphtheria; suppurating Gland below Right Jaw.

Female, aged 4 years. Admitted to the Middlesex Hospital, under the care of Dr. Finlay, June 13th, 1891. Died June 20th, 1891.

Duration of illness.—June 11th–June 20th: 10 days.

History.—Measles at 2½ years. Ten days before death, diarrhœa, vomiting, and headache; on next day sore throat with continuance of the diarrhœa. On the third day of illness there was dyspnœa, the diarrhœa and vomiting ceasing. On admission the temperature was 97·6° F., R. 42, and P. 138. There was membrane on the tonsils, and in the pharynx.

During stay in hospital the temperature rose twice to 100° F., six days before death and two days before death. Two days before death there was well-marked dyspnœa, and on the day of death there was sighing breathing, death occurring somewhat suddenly.

Post-mortem examination.—6½ hours after death.

Body well nourished.

Tonsils, congested, and covered with purulent looking mucus; no membrane. *Pharynx*, congested; no membrane.

Enlarged *gland* size of a chestnut, suppurating below right angle of jaw.

Cultivations made from tonsils and the gland. Numerous micro-organisms obtained, but not the *bacillus diphtheriæ*.

Larynx, normal.

Lungs, normal.

Heart.—Muscle pale, firm (cloudy swelling).

Liver and spleen, congested.

Kidneys, cortex pale.

Blood, fluid, coagulates imperfectly.

Remarks.—This case illustrates one form of diphtheria in which the membrane is limited to the throat, but disappears as such before death; a secondary pus affection of the glands below the jaw occurring. It is noticeable that the heart was affected, the pulse being 138 on admission into the hospital, and that the patient for two days before death suffered from dyspnœa, although there was no obstruction to respiration.

Case 4.—Pharyngeal and Laryngeal Diphtheria. Tracheotomy.

Male, aged 14 months. Admitted to the Middlesex Hospital, under the care of Dr. Cayley, July 7th, 1891. Died July 11th

Duration of illness.—July 2nd–11th: nine days.

History.—Nine days before death, a "cold in head," followed in five days by "croup." Admitted to hospital, temperature varied between 98·4° to 101°, but rose to 102° F. at death. Tracheotomy four days before death.

Post-mortem examination.—12 hours after death.

Body well developed and well nourished. Rigor marks absent. No œdema.

Pharynx congested. Pultaceous membrane in larynx and trachea down to medium-sized bronchi. Recent tracheotomy wound.

Lungs normal.

Heart, *liver*, *spleen*, and *kidneys* normal to naked eye.

The membrane examined microscopically showed numerous "diphtheritic" bacilli and numerous cocci.

Remarks.—This case was one associated with moderate fever, and presented the ordinary features of pharyngeal diphtheria spreading down the larynx.

Case 5.—Pharyngeal and Laryngeal Diphtheria. Tracheotomy.

Male, aged 3½ years. Admitted to the Middlesex Hospital, under the care of Dr. Cayley, July 9th, 1891. Died July 13th.

Duration of illness.—July 7th–13th: seven days.

History.—Ill on July 2 (12 days before death) with enlarged glands in neck and torticollis; got better. On July 7 (seven days before death) sore throat; on the next day some sensation of choking. Five days before death a croupy cough with dyspnœa.

When admitted to the hospital there was almost complete aphonia, with membrane on the tonsils and a nasal discharge. Tracheotomy relieved somewhat. The temperature after tracheotomy varied between 99·5° and 103·2° F., falling to 98·6° on the day of death.

Post-mortem examination.—Four hours after death.

Body well developed and well nourished. Rigidity absent. No œdema.

Pharynx and larynx contained pultaceous membrane, which also extended down the trachea and as far as the end of the two large bronchi.

Lungs.—Patches of broncho-pneumonia in both lungs.

Heart and *spleen* normal. *Liver* congested. *Kidneys* pale.

Blood dark, semi-fluid; with clots.

Remarks.—This case calls for no particular remark. It presented features similar to Case 4.

Case 6.—Nasal and Pharyngeal Diphtheria.

Female, aged eight years. Admitted to University College Hospital, under the care of Dr. Sidney Martin, September 10th, 1891. Died September 11th.

Duration of illness.—Four days: September 7th–11th.

History.—Illness began on September 7th with a sore throat and vomiting. On the next day the neck was swollen, and there was some difficulty of swallowing and breathing. On admission to the hospital (September 10th) the neck was greatly swollen and œdematous, the glands below jaw being enlarged. The tonsils were greatly enlarged and, as well as the pharynx, covered with thick tough yellowish grey membrane. Breathing rapid and snoring. Pulse, 160; temperature, 103·2° F. The temperature remained high (104° F.). The patient became very restless, and died in coma.

Post-mortem examination.—13½ hours after death.

Body well developed and well nourished. Slight rigidity. No œdema.

Fauces, *tonsils*, *pharynx*, and upper surface of *epiglottis* covered with adherent tough membrane and a thick slightly bloodstained fluid, somewhat offensive. Sanious mucous discharge at nostrils. *Larynx* and *trachea* normal. Great swelling of neck below jaw; *lymph glands* enlarged and deeply congested, no suppuration.

Lungs show numerous ecchymoses, sub-pleural and in substance, and congestion of bronchi. No consolidation.

Heart and *liver* normal. *Spleen* enlarged and deeply congested. *Kidneys* pale.

Remarks.—This was a very rapid case, with high fever, restlessness, prostration, and death in coma; illustrating the features of "malignant" diphtheria. There was some obstruction to respiration from the greatly enlarged tonsils, and the thick membrane in the pharynx and fauces.

CHEMICAL PATHOLOGY OF DIPHTHERIA.

(*Intravenous injection of Albumoses.*)

PLATE I.

Figs. 1, 2, and 3 were reproduced from photographs* of experimental animal No. 5 (page 155).

FIG. 1.

Shows the rabbit on the fourth day of experiment. On this day there was some weakness of the hind legs, the left leg being somewhat weaker than the right, and held in a position of slight abduction.

FIG. 2.

Shows the condition of the animal on the nineteenth day. Between the fourth and nineteenth day there was progressive weakness, which was suddenly increased on the nineteenth day. As the picture shows the hind legs were paralysed; they were held in the position seen. The fore legs were affected as well as the trunk muscles. Attempts at jumping evoked irregular movements of the limbs ending in dyspnœa.

FIG. 3.

Shows the animal on the fifty-fourth day of experiment. Recovery from the condition seen on the nineteenth day was nearly complete. Some weakness of the hind legs alone remaining.

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* These photographs are by Mr. Doudney, attendant at the Conjoint Laboratories; elsewhere in this report, except where otherwise stated, photographs are by Mr. Andrew Pringle. All reproductions of photographs are by the Autotype Company.

IG. 1.

IG. 2.

IG. 3.

PLATE II.

Fig. 4.

CHEMICAL PATHOLOGY OF DIPHTHERIA

(Intravenous injection of Albumoses.)

PLATE II.

FIG. 4.

Reproduced from a photograph. Magnifying power × 25 diam. A small intramuscular branch of the nerve to the *Triceps brachii* from experimental rabbit No. 4 (page 157).

The nerve was mounted whole after staining in osmic acid, and after removing the perineurium with needles.

The figure shows that just before the nerve gives off a small branch, two portions of the trunk are attenuated, are unstained by the osmic acid, and are separated by a stained portion. The appearances here seen are those observed in all the nerves affected by degeneration resulting from injection of the diphtheria albumoses.

CHEMICAL PATHOLOGY OF DIPHTHERIA.

(Intravenous injection of Albumoses.)

PLATE III.

FIG. 5.

Represents a branch of the nerve to the vastus muscle from a rabbit (No. 4), weighing 1,565 grammes, which had received intravenously two doses of diphtheria albumoses, equal to 0·1 gramme per kilo. of body weight (pages 157–8). The nerve after staining in osmic acid, was examined in each of several portions, viz., between the transverse lines (1–7) in the drawing.

The portions of the nerve depicted black are those which were found normal.

The lighter parts were found degenerated, and at D, showed the advanced degeneration described in the text.

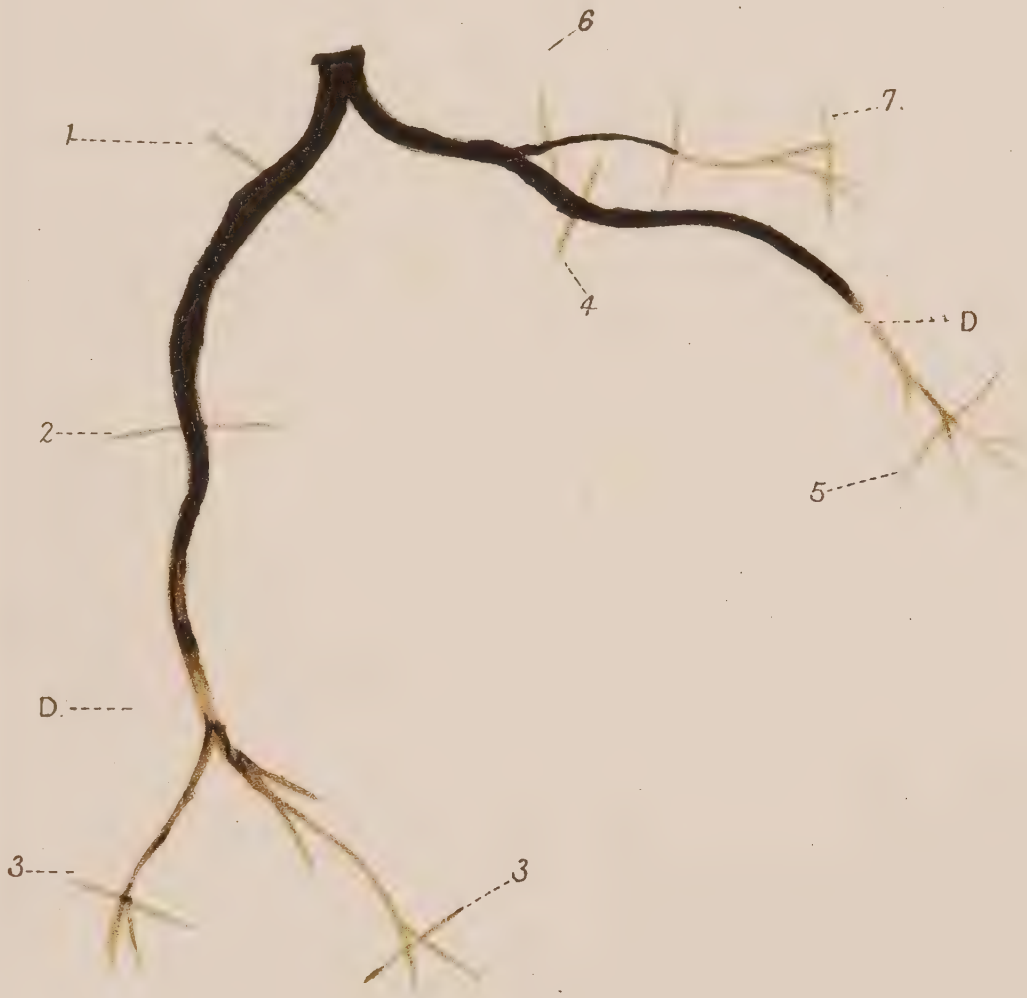
The nerve between 1 and 2 was normal.

,, ,, 2 ,, 3 was normal above, degenerated at D, and partially degenerated below.

,, ,, 4 ,, 5 showed the same features as between 2 and 3.

,, ,, 6 ,, 7 showed early degeneration at the periphery.

[Plate IV. (Figs. 6, 7, 8), and Plate V. (Figs. 9, 10), are autotype reproductions of photographs of the nerve fibres passing between the transverse lines 2 and 3 of this figure.]



Nerve to Vastus.

Fig. 5.

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PLATE IV.

FIG. 6.

FIG. 7.

FIG. 8.

CHEMICAL PATHOLOGY OF DIPHTHERIA.

(*Intravenous injection of Albumoses.*)

PLATE IV.

Figs. 6, 7, 8, and Plate V., Figs. 9 and 10, are to be studied in sequence from above downwards. They are reproductions of photographs of nerve fibres (× 35 diam.) of the nerve to the vastus, represented by the drawing on Plate III., and taken from the same animal as the nerve depicted in Plate II. (Fig. 4). (Experimental animal No. 4.)

Referring to Plate III., the branch of the nerve on the left was split from above the degenerated portion to the end of the small branches; a few nerve fibres were separated, and the Figs. 6–10 represent the appearances successively from just above the degenerated portion to the end of the small branches.

FIG. 6.

At the upper part the two nerve fibres shown are deeply stained by the osmic acid (the break in continuity of the fibres was caused by the teasing needles); below, the white substance has become thin for a short distance, it reappears again, and again disappears; this last disappearance is at the degenerated portion shown in Plates II. and III.

FIG. 7.

The disappearance of the white substance is continued through Fig. 7; the white substance reappearing at the lower part of the figure.

FIG. 8.

Below this, as in Fig. 8, the white substance is thin. This is not well shown in the photograph, as the two nerve fibres were lying very close together.

CHEMICAL PATHOLOGY OF DIPHTHERIA.

(Intravenous injection of Albumoses.)

PLATE V.

FIG. 9.

Shows, in continuation of Plate IV., the presence of white substance in the nerve fibres to the vastus muscle.

FIG. 10.

Is in continuation of Fig. 9, and terminates the series, Figs. 6–10. At the middle of the figure three nerve fibres are seen stained black, but not quite normal, as the segments of white substance are very short as compared with the unaffected nerve fibres at the lower part of the figure.

In this series of figures it is seen that although the white substance may completely disappear from a portion of a nerve fibre, the fibre thus affected does not necessarily degenerate towards the periphery. But the photographs do not bring out a fact which is evident in the microscopical specimen: viz., that throughout the degenerated portion of the nerve fibres here depicted the axis cylinders can be seen, and that only one is ruptured (*see* succeeding Fig. (11)).

FIG. 11.

Is reproduced from a photograph of a nerve fibre from the same nerve under a higher power, × 320 diam. The figure shows almost complete absence of white substance from a portion of the fibre. In the middle of the fibre the axis cylinder is seen ruptured in two places, so that a portion is isolated and has become tortuous. The axis cylinder is stained black by the osmic acid, a sign that it has degenerated.

Fig. 9.

Fig. 10.

Fig. 11.

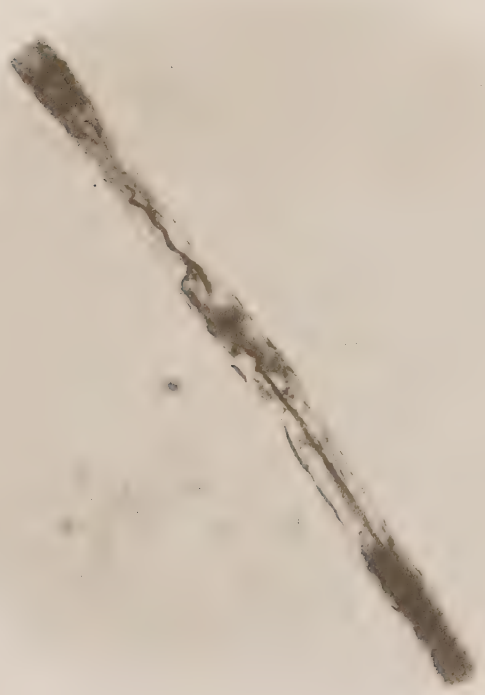

PLATE VI.

FIG. 12.

FIG. 13.

FIG. 14.

CHEMICAL PATHOLOGY OF DIPHTHERIA.

(*Intravenous injection of Albumoses.*)

PLATE VI.

Fig. 12.

Depicts ruptured axis cylinder. It is reproduced from a photograph of fibres (× 160 diam.) of the nerve to the soleus (page 137). The animal (experimental animal No. 4) whence the specimen was taken is the same that supplied the nerves depicted on Plates IV. and V.

The figure shows three nerve fibres, lying side by side, stained with osmic acid. The white substance is thinner than normal, as shown by its not staining black: the axis cylinders lie in the centre of the fibres and are stained black. In the lower two fibres they are wavy and irregular in thickness. In the upper fibre, if the axis be traced along the fibre, it is seen to end abruptly, and to disappear for a space; then to appear again with a knobbed end, after which it becomes wavy. The knobbed end is attached to the proximal part of the axis. (In parts the fibres have been damaged by the teasing needles.)

Fig. 13.

Reproduced from a photograph of another part (× 160 diam.) of the same microscopical specimen as in Fig. 12. It shows the wavy axis cylinders in the attenuated white substance. The waviness is a sign that the axis is ruptured in one part of its course.

Fig. 14.

Reproduced from a photograph of the teased nerve fibres of the left phrenic nerve (× 150 diam.) It shows a portion of the nerve in which the white substance is attenuated and broken up into small segments. Taken from experimental animal No. 3 (page 136).

CHEMICAL PATHOLOGY OF DIPHTHERIA.

(Intravenous injection of Albumoses.)

PLATE VII.

FIG. 15.

Reproduced from a photograph of a bundle of nerve fibres in an anterior root of a dorsal spinal nerve, removed from experimental animal No. 4 (page 159): × 120 diam. At the middle part of the picture, the nerve fibres have lost their white substance. Under a higher power, some of the axis cylinders could be traced intact through this part.

FIG. 16.

Reproduced from a photograph of nerve fibres in the phrenic nerve of the animal injected with extract of *diphtheria membrane* (page 159): × 350 diam. At the right side of the figure, the white substance has disappeared in great part from the fibres: in other parts it is seen broken into short fragments. The second nerve fibre from the right shows a straight line running through it, which under a higher power is seen to be the axis cylinder.

(*See also* Plate IX., fig. 21.)

FIG. 17.

Reproduced from a photograph of nerve fibres to the Biceps brachii from experimental animal No. 4 (page 159). It shows the earliest stage of the degeneration (× 130), which consists in the breaking up of the white substance while the axis cylinder is intact. See the nerve fibre on the right. Above and below the region of degeneration, the nerve fibres were perfectly normal.

FIG. 15.

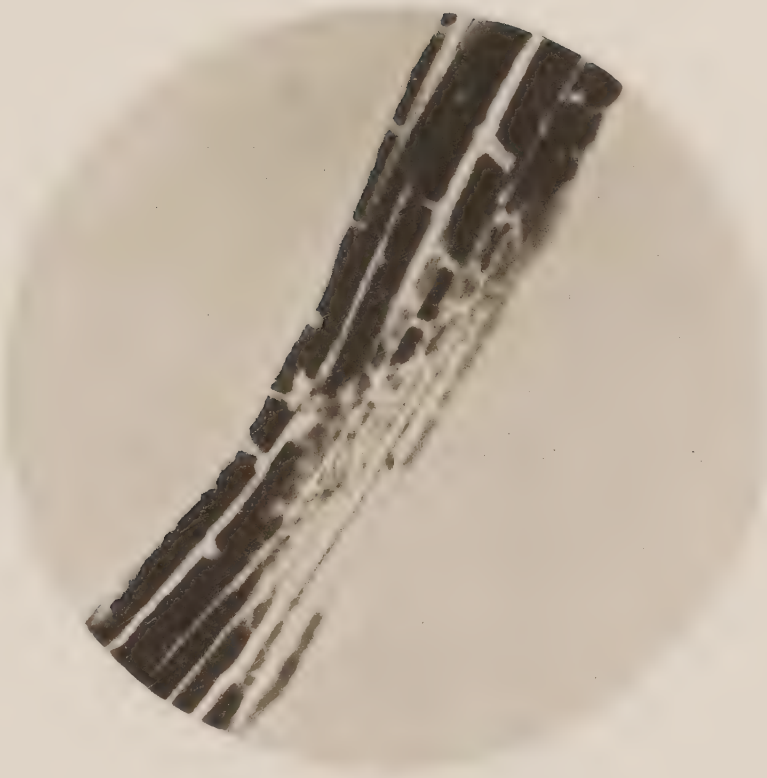

FIG. 16.

FIG. 17.

PLATE VIII.

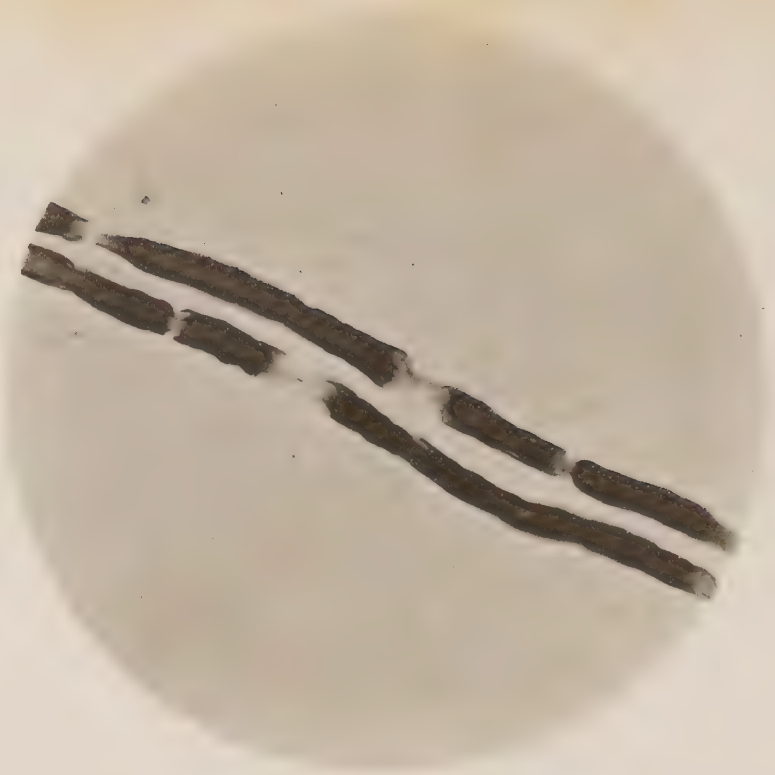

FIG. 18.

FIG. 19.

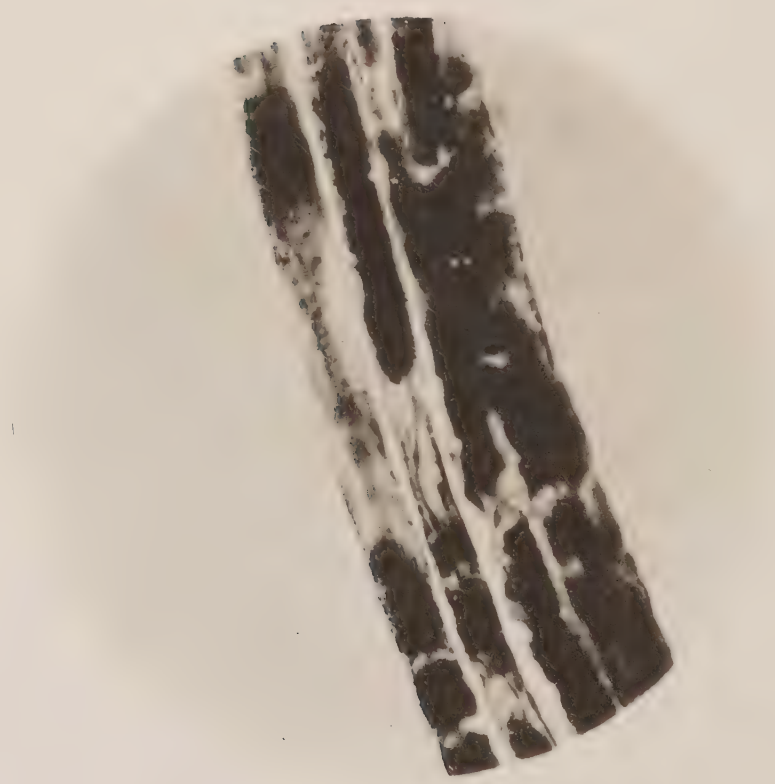

FIG. 20.

CHEMICAL PATHOLOGY OF DIPHTHERIA.

(Intravenous injection of Albumoses.)

PLATE VIII.

FIG. 18.

Reproduced from a photograph of fibres in the phrenic nerve from the rabbit injected with extract of *diphtheria membrane* (page 159) : ×375 diam. The figure shows loss of the white substance in a part of the segment of a nerve. In the lower nerve fibre the axis cylinder is seen as a thin dark line in the degenerated part.

FIG. 19.

Reproduced from a photograph of a fibre (× 375) in the same nerve as shown in Fig. 18. The degeneration is more extensive. The axis cylinder is seen as a thick dark line which has become attenuated lower down.

Figs. 18 and 19 represent very accurately what Gambault described as "névrite segmentaire péri-axile" (*see* text, page 159).

FIG. 20.

Reproduced from a photograph of five fibres (× 375) in the phrenic nerve from experimental animal No. 4. The nerve fibres show breaking up and attenuation of the white substance. The nerve fibre on the left shows the axis cylinder as a thick dark cord ruuning through the nerve fibre. In the fibre next to it, the axis is attenuated and wavy. This phrenic nerve was practically normal in its course in the neck : the degenerated portion was found in the upper thoracic region : a few degenerated fibres were found in the small branches on the diaphragm.

CHEMICAL PATHOLOGY OF DIPHTHERIA.

(*Intravenous injection of Albumoses.*)

PLATE IX.

FIG. 21.

Reproduced from a photograph* of a bundle of fibres in the phrenic nerve of an animal injected with extract of *diphtheria membrane*, × about 50 diam.

The figure shews degeneration of the nerve fibres at two parts, representing the early stage of multiple degeneration. The breaking up of the white substance and its attenuation are well seen, even under the low power employed in this photograph. The upper degenerated part is represented under a high power in Fig. 16, Plate VII. (The black mass below the second degeneration is some adventitious matter which accidentally floated over the specimen during its preparation.)

FIG. 22.

Reproduced from a photograph of fibres × 160 diam., in the nerve to the gastrocnemius from the animal injected with extract of *diphtheria membrane*. The figure shows the later stages of multiple degeneration. There were at least four degenerated portions of the nerve, seen by local shrinking of the nerve trunk. The nerve fibres are completely degenerated; the primitive sheath, and a few droplets of white substance being left.

FIG. 23.

Reproduced from a photograph of the same nerve fibres as shown in Fig. 22, but under a higher power, × 375 diam. Here the remnants of the axis cylinder are seen.

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* Photograph by Mr. Doudney.

FIG. 21.

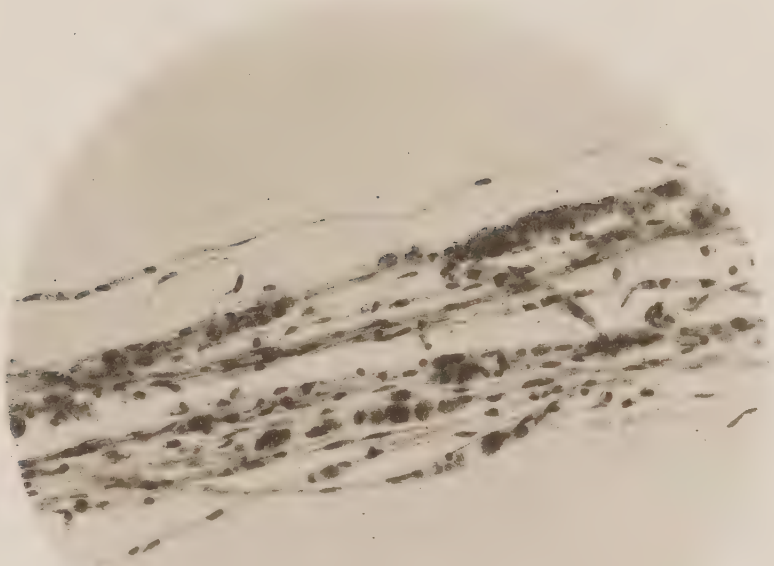

FIG. 22.

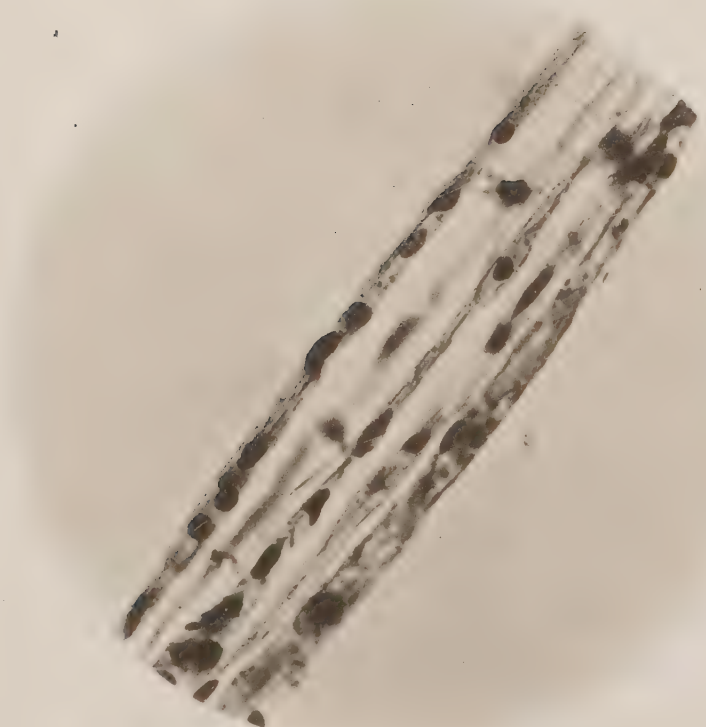

FIG. 23.

PLATE X.

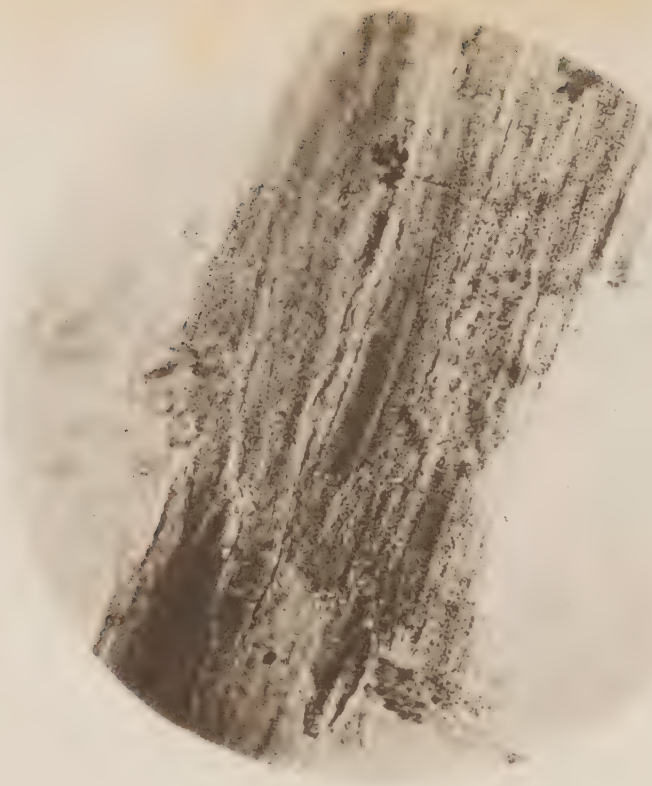

FIG. 24.

FIG. 25.

FIG. 26.

CHEMICAL PATHOLOGY OF DIPHTHERIA.

(Intravenous injection of Albumoses.)

PLATE X.

FIG. 24.

Reproduced from a photograph of fatty degenerated muscle fibres of the heart, stained with osmic acid × 350 diam. The specimen photographed was taken from the animal injected with extract of *diphtheria membrane*. The fatty granules are seen as minute round dots.

FIG. 25.

Reproduced from a photograph of the teased nerve bundles of a sensory nerve (the long saphenons) from experimental animal, No. 4, × 255 diam. The degeneration is of the same nature as in the moter nerves, and is shown in the uppermost bundle of nerve fibres (page 160).

FIG. 26.

Reproduced from a photograph of a part of the cervical sympathetic trunk just above the third ganglion, from experimental animal No. 4, × 60 diam. The attenuation of the nerve fibres is well shown. Above the degenerated portion the fibres were normal; below, a few were degenerated. The specimen was stained with osmic acid and counter-stained with borax-carmine.

CHEMICAL PATHOLOGY OF DIPHTHERIA.

(Intravenous injection of Albumoses.)

PLATE XI.

FIG. 27.

Represents the Anterior Crural and Sciatic nerves of the left hind leg of a rabbit, weighing 1,565 grammes, which had received intravenously two doses of diphtheria albumoses, equal together to 0·1 gramme per kilo. of body weight.

The lower lumbar nerves and the upper sacral are shown. The normal parts of the nerves are coloured black, the degenerated parts being represented by a lighter colour. Where there was "interrupted degeneration," this is shown by interruptions of the shading.

The central parts of the nerves are seen to be normal, the peripheral parts, chiefly the intramuscular branches, are degenerated. The nerves were excised with a piece of muscle attached and stained with osmic acid.

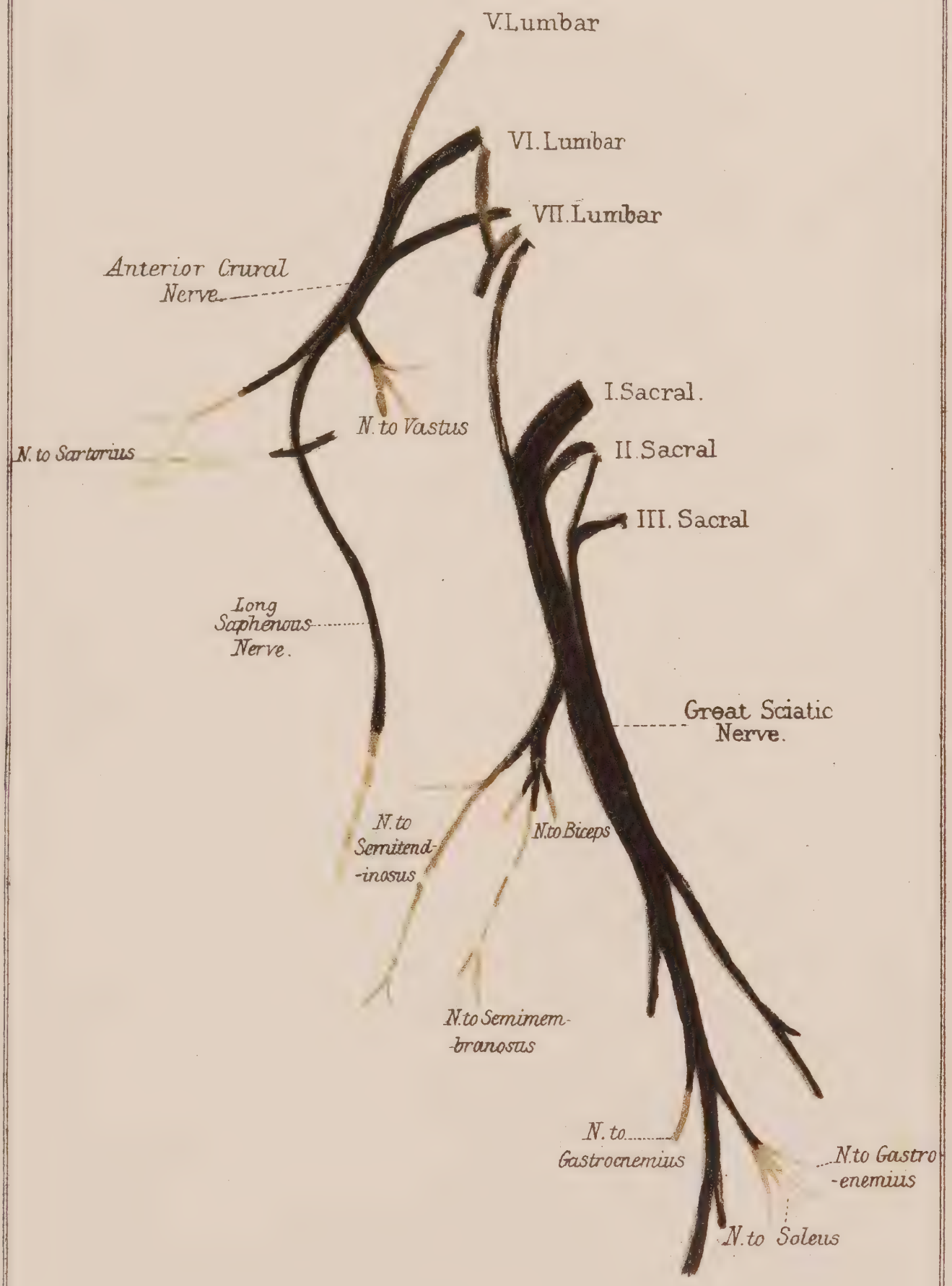

Fig. 27.

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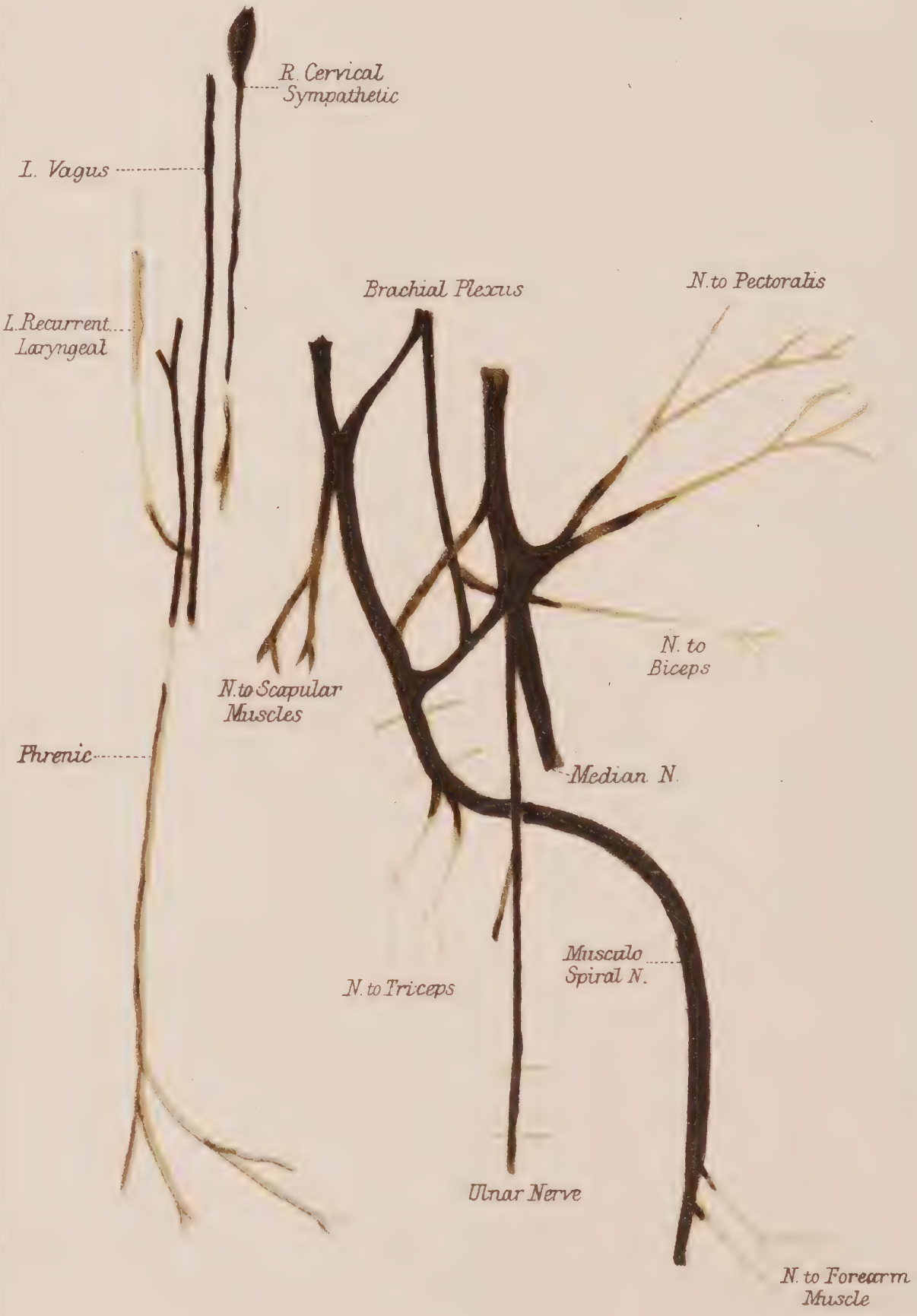

Fig 28.

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CHEMICAL PATHOLOGY OF DIPHTHERIA.

(Intravenous injection of Albumoses.)

PLATE XII.

FIG. 28.

Represents the nerves of the left fore leg of the rabbit referred to in Plate XI., and as well the phrenic and visceral nerves (vagus and sympathetic). As in Plate XI. those portions of the nerves found to be normal are coloured black; the degenerated parts are lightly coloured. The musculo-spiral and the ulnar trunks were examined in sections between the transverse lines, and were found normal.

CHEMICAL PATHOLOGY OF DIPHTHERIA.

(Intravenous injection of Organic Acid.)

PLATE XIII.

FIG. 29.

Represents the degeneration of nerves produced in the rabbit by the intravenous injection of the *Organic Acid* obtained from the tissues of diphtheria patients (page 165).

(*a*.) Represents the nerve to the Semi-membranosus muscle.
(*b*.) ,, a branch of the nerve to the Vastus internus muscle.
(c^1.) ,, the *whole of* the nerve to the inner head of Gastrocnemius.
(c^2.) ,, a projection of each branch of the nerve depicted at (c^1).

This specimen afforded a good illustration of the very partial manner in which the nerve may be affected by the degeneration.

Rabbit 1180 Grammes. Two doses of organic acid into Marginal vein = 0·095 g. per Kilo. of body wt Killed in 24 days.

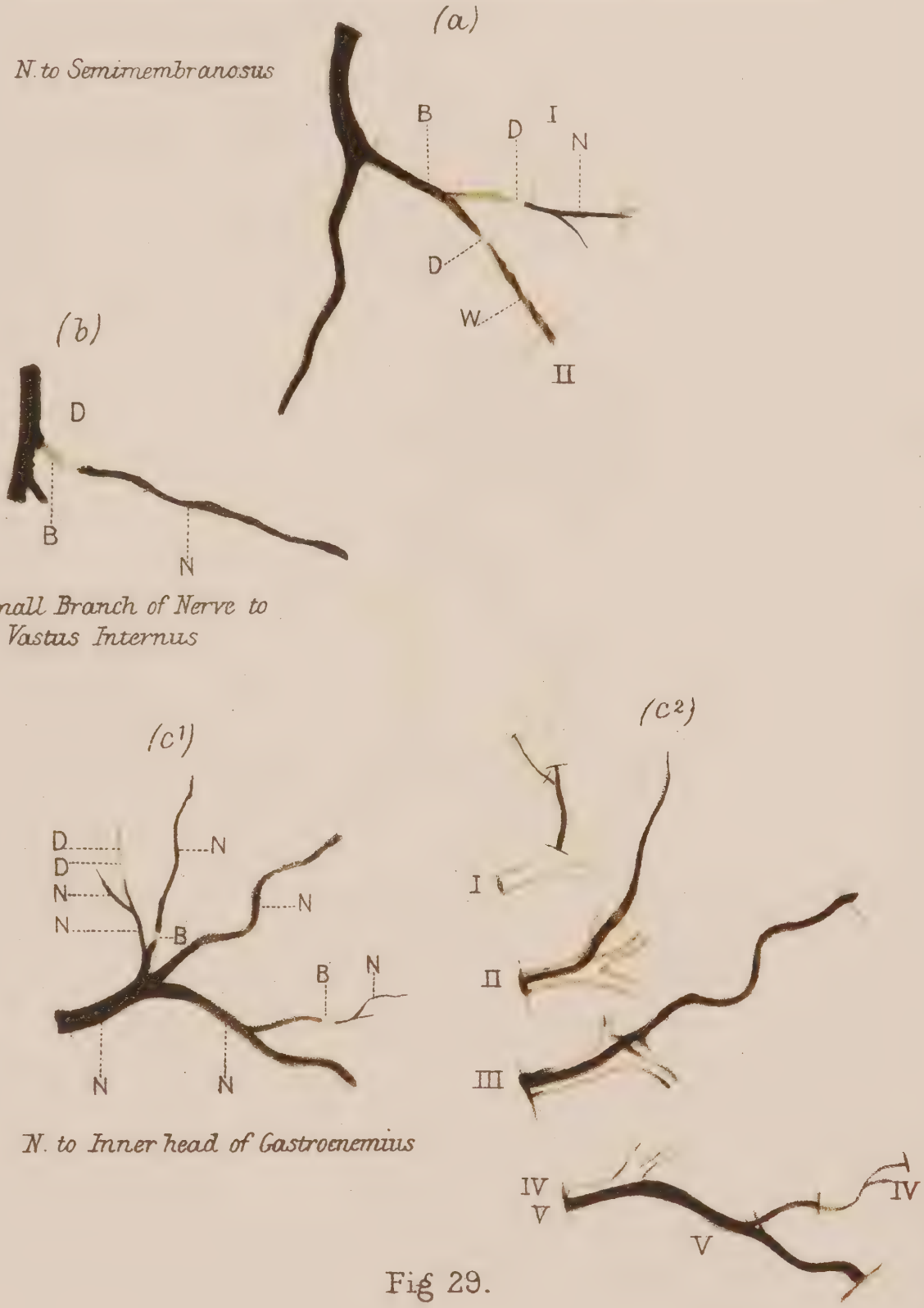

Fig 29.

B. *Breaking up of White Substance.*
D. *Degenerated Portion.*
W. *Commencing Wallerian Degeneration*
N. *Normal*

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PLATE XIV.

FIG. 30.

FIG. 31.

FIG. 32.

CHEMICAL PATHOLOGY OF DIPHTHERIA.

(*Intravenous injection of Albumoses.*)

PLATE XIV.

Figs. 30, 31, and 32 are reproduced from photographs* of the rabbit injected with extract of *diphtheria membrane* (page 166).

FIG. 30.

Reproduced from a photograph taken on the fifth day of experiment. The rabbit was very well, but manifested paresis of the hind legs, with abduction of the left leg, as shown in the figure.

FIGS. 31 *and* 32.

Reproduced from photographs taken about 12 hours before death on the 13th day of experiment. Fig. 31 shows the animals paralysed apparently in all its limbs; but, as shown in Fig. 32, the hind legs were not completely paralysed as they could be drawn into the position of flexion.

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* Photographs by Mr. Doudney.

CHEMICAL PATHOLOGY OF DIPHTHERIA.

[INFECTIVE ENDOCARDITIS.]

PLATE XV.

FIG. 33.

Reproduced from a photograph of a microscopical section stained with methylene blue of a vegetation on the mitral valve in the case of infective endocarditis described at page 172 of report : ×70 diam.

At the lower part of the figure a small portion of the valve tissue is shown, the small dots being the cells and the striations representing connective tissue.

In the rest of the figure is shown the mass of fibrin capping the valve, and at the edge of the fibrin there is a dark fringe, which, under a high power, is seen to be composed of micrococci. The fringe is well seen on the right of figure, and several isolated colonies of cocci are to be observed here.

FIG. 34.

Reproduced from a photograph of the micrococci obtained by cultivation from the valve depicted in Fig. 33 : ×1,000 diam. The cocci are seen in clusters, and are staphylococci.

FIG. 33.

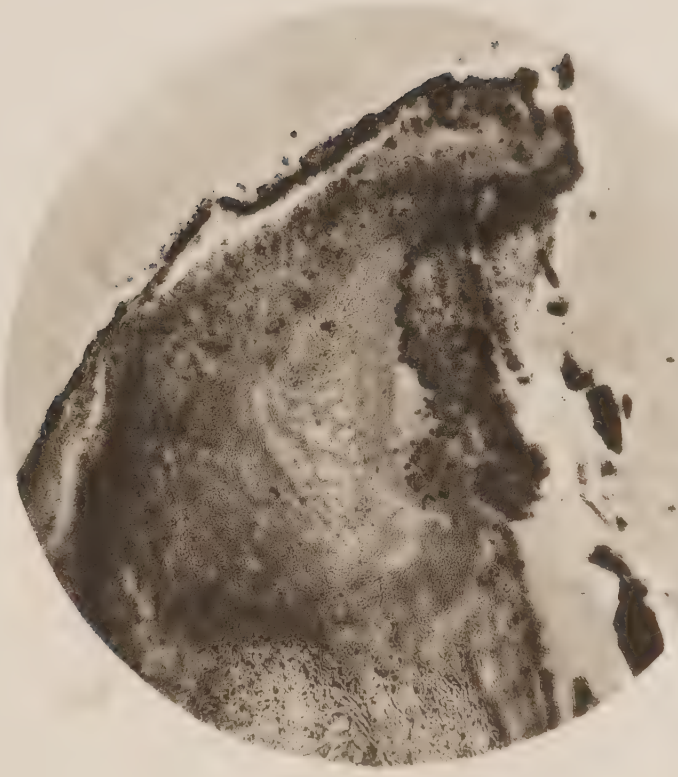
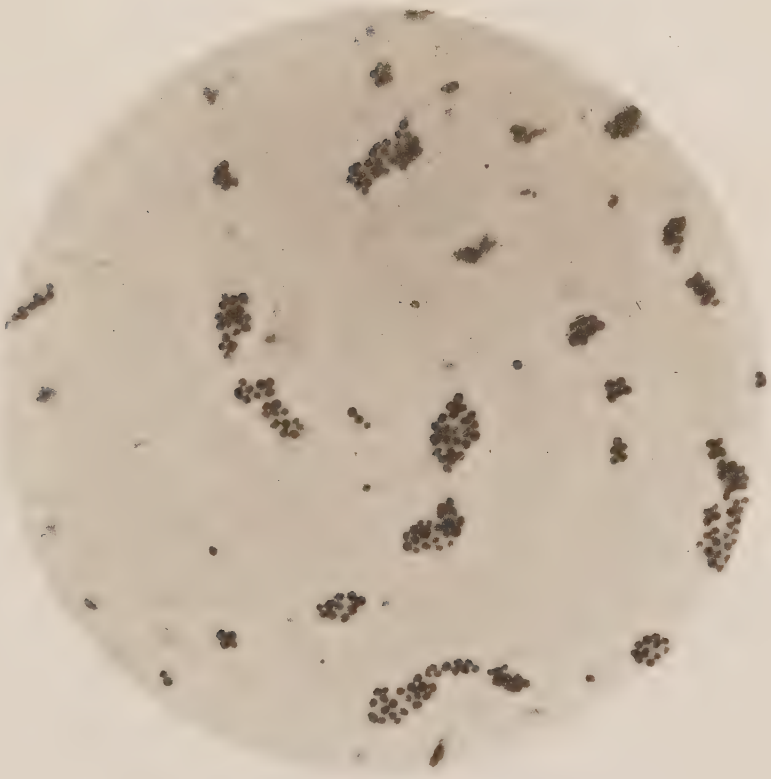


FIG. 34.



No. 5.

Further Report on the Conditions determining Insusceptibility; by W. H. Hamer, M.D.

On the Conditions determining Insusceptibility; by Dr. W. H. Hamer.

The conditions determining insusceptibility of the animal body to infection admit, as was remarked in a previous report, of being considered from two points of view.

Diverse views of insusceptibility.

On the one hand, it has been maintained that certain vitalised tissue elements possess the power of eating up and destroying invading microbes. This doctrine of phagocytosis has been the subject of much adverse criticism, and the results of my own investigations have tended strongly in support of the view that the problems of insusceptibility are not to be satisfactorily solved solely by an appeal to phagocytes.

On the other hand, it has been suggested that certain chemical substances in animal tissues play an important part in determining the susceptibility or insusceptibility of the body to infection.

The germicidal influence of ferments to be considered.

In the present research this aspect of the question has alone been dealt with; for inasmuch as certain substances, known as ferments, exercise important functions in the animal economy, and have moreover been credited with germicidal powers, it was thought desirable to endeavour to ascertain whether any, and, if any, what, basis of fact existed to warrant the conclusion that these ferments play a part in determining the insusceptibility of the animal body to infection.

The ferment of the saliva, that of the pancreas, and the blood ferment, have all been indicated as possibly possessing an inimical action upon the growth and development of bacterial life. The exact experiments made with a view to determining accurately the existence and extent of the power of each in retarding or inhibiting multiplication of microbes are, however, very few in number.

Dr. Berry Haycraft has made some observations upon the behaviour of solutions containing saliva, which have suggested the preliminary experiments of which details will be given in this report. The blood ferment, too, which is also dealt with, has been experimented with by other observers in a somewhat similar connexion.

I.—*Experiments with Saliva.*

Inhibitory influence exerted by the salivary secretion upon the growth of certain micro-organisms.

Dr. Haycraft found that a solution containing ordinary saliva remained clear and free from evidence of putrefactive change for several days. He compared two fluids of identical composition, both containing a small amount of saliva; the one having been subjected for a few minutes to the temperature of boiling water, the other not having been so subjected. These two fluids were kept by him under like conditions; but with this difference, namely, that the fluid which had been boiled was, after sterilisation in this way, inoculated with a trace of the other (the unboiled) fluid. As a result, it was found that the fluid which had been boiled soon showed marked evidences of putrefactive changes, whereas the unboiled fluid remained quite sweet and clear for many days.

Since the conditions of experiment had been, so far as could be seen, so devised as to ensure identity of the two fluids in all respects save one,—namely, that one fluid contained an uninjured and active ferment, while in the other fluid the ferment had been destroyed by raising the temperature to boiling point,—it was concluded by Dr. Haycraft that the salivary ferment possessed a distinct power of inhibiting the growth of putrefactive micro-organisms.

With a view to inquiring into the phenomena observed by Dr. Haycraft in some detail, the following experiments were undertaken.

Experiment I.—A mixture was (on 19th June 1891) made containing 370 c.c. of sterile normal saline solution, 15 c.c. of sterile 1 per cent. solution of peptone, and about 15 c.c. of human saliva. This mixture was divided into equal parts, and each part was placed in a sterilised flask of some 400 c.c. capacity; both flasks being immediately plugged with sterile cotton wool.

The fluid in one flask, B, having been boiled for one minute, was allowed to cool, and was then inoculated with a trace of the material in the other flask, A. The two flasks (A and B) were then incubated at a temperature of 37° C.

After the lapse of 24 hours, flask A (unboiled) was found to have a whitish-grey sediment, the supernatant fluid being quite clear. A drop of this fluid removed with a capillary pipette and examined under the microscope showed no evidence of the presence of micro-organisms.

The fluid in the flask B (which had been boiled), on the other hand, was by this time turbid, and on microscopical examination was found to contain abundant bacterial growth. The contained organisms proved, on examination under the microscope, to be actively motile bacilli.

With a drop of fluid from each flask plate cultivations were made.

After the lapse of a few days, the plate made from flask B (the flask which had been boiled) showed abundant colonies which slowly liquefied the gelatine, and which when microscopically examined were found to consist of motile rods. Further careful investigation in subculture of these colonies, demonstrated the fact that the organisms belonged to the group known as bacillus subtilis.

The plate, however, made from the flask A (unboiled) only developed four colonies; so that the fluid in that flask clearly contained comparatively speaking a very small number of micro-organisms.

As regards the original flasks:—At the end of 72 hours the fluid in B had become markedly turbid, and on the surface it presented a distinct scum. The fluid in A meanwhile remained clear, and no scum had appeared; but floating in it two or three colonies of a mould (penicillium) could be detected. A drop from flask A now showed under the microscope a few of the mould hyphæ; while a drop taken at the same time from flask B showed countless multitudes of the motile rods of bacillus subtilis.

Experiment II.—In this experiment (commenced 22nd June) nutrient solution containing a considerably larger per-centage than before of peptone was employed. Thus—

50 c.c. of a 2 per cent. solution of peptone, 10 c.c. of saliva, and 140 c.c. of sterile salt solution were mixed together; a third part of the mixture being then placed in each of three flasks, A, B, and C.

Flask A was not subjected to any further treatment.

Flask B was boiled for one minute, cooled, and then inoculated with a trace of flask A.

Flask C (unboiled) was inoculated with bacillus subtilis.

The flasks were incubated at 37° C.

Flasks A and B remained comparatively clear and free for many days from evidence of any marked bacterial growth.

Flask C rapidly developed a scum, and there was obviously an abundant growth of bacillus subtilis in it.

This result was not in accordance with the previous one, and it was conjectured that the richness of the nutrient solution in peptone *might* be a vitiating element, since peptone is known to Physiology to exert an unfavourable influence upon the action of the salivary ferment, as also upon that of the blood ferment. Accordingly in subsequent experiments the employment of peptone was discontinued.

Experiment III.—Here 5 c.c. of saliva were (on 25th June) mixed with 5 c.c. of sterile saline solution, and one half of the mixture was placed in each of two sterile test-tubes. One of these tubes was boiled and then cooled. Both tubes were then inoculated with material from a culture of bacillus subtilis, and were incubated at 37° C.

The tube the contents of which had been boiled, rapidly became turbid, and developed a scum. The fluid in the other tube remained clear, and no scum appeared.

On the sixth day (June 30th) plate cultures were made with the object of testing the nature of the bacterial growth (if any) in the two tubes.

The plate made with a trace of material from the tube which had been boiled, developed a large number of colonies of bacillus subtilis.

The plate made with a trace of material from the other tube which had not been boiled, developed a few colonies only of bacillus subtilis.

On the tenth day (July 4th) plate cultivations from the two tubes were again made.

The plate made with a trace of material from the tube which had been boiled, again developed a large number of colonies of bacillus subtilis.

The plate made with a trace of material from the other tube which had not been boiled, developed no colonies.

Experiment IV.—This experiment (commenced 26th June) was conducted on the same lines as Experiment III. 5 c.c. of saliva were mixed with 200 c.c. of sterile saline solution, and one half of the mixture was placed in each of two flasks. Only one of these flasks was then boiled and cooled, and both flasks were then inoculated with bacillus subtilis, and were incubated at 37° C.

The result was confirmatory of that obtained in the preceding experiment.

The fluid in the flask which had been boiled developed a scum; and—

A plate cultivation therefrom, 27th June, developed abundant colonies of bacillus subtilis; and similarly a plate cultivation therefrom three days later (30th June), showed abundant colonies of bacillus subtilis.

The fluid in the other and unboiled flask meanwhile remained clear, and no scum appeared. A plate cultivation therefrom, 27th June, developed a few colonies only of bacillus subtilis; and a plate cultivation therefrom three days later, developed no colonies.

Experiment V.—This experiment was conducted in the same manner as the two preceding ones, and with a similar result.

There can thus be no doubt as to the fact that boiling the saliva-containing fluid, substantially affected the capacity of such fluid for development of the particular organism, bacillus subtilis.

II.—Experiments with Pancreatic Extract.

Experiments with glycerine extract of the pancreas of a dog.

In the experiments made with saliva which have just been described, a fluid was being dealt with which contained a ferment. But no attempt was made to isolate that ferment,—to separate it from the other substances present in the saliva. It was of course fully recognised that such separation of the ferment was desirable, and from the outset it was decided that the most satisfactory material from which to obtain an extract possessed of active fermentative properties would be the pancreas.

Accordingly, on June 20 (the day after starting the first saliva experiment), a young dog was killed, and its pancreas having been

removed was allowed to remain under a bell-jar for 24 hours. The gland was then cut up into small pieces, mashed up with glycerine in a mortar, and then placed to stand in a stock bottle containing some six or eight ounces of glycerine.

On June 30th this pancreatic extract was tested and found to be possessed of very marked amylolytic properties.

The following experiment was then performed :—

The behaviour of the glycerine extract when inoculated on gelatine.

A drop of the extract was removed from the stock bottle with a sterilised capillary pipette, and transferred to a gelatine tube with a slanting surface such as is used in making streak cultures; the drop of extract being by means of a sterile platinum needle throughly spread out over the whole surface of the gelatine.

A second drop of extract was diluted by transference to a test-tube containing 10 c.c. of sterile salt solution with which it was thoroughly shaken up. A drop of the resulting mixture was then by means of a capillary pipette, placed upon the slanting surface of gelatine in a tube, and thoroughly dispersed over the gelatine. The two gelatine tubes were incubated at 20° C.

It was anticipated that the first tube would after a day or two show innumerable colonies of bacteria, and that in the second tube, in which the material inoculated had been considerably diluted, possibly only a few colonies would appear.

The result was somewhat of a surprise; for while the gelatine in both tubes became rapidly liquefied, the liquid gelatine remained in each instance perfectly clear. There was no development of scum, of turbidity, or of flocculent material, such as is usually associated with the growth of bacteria.

The suggestion accordingly presented itself that possibly the pancreatic extract was sterile, and that the liquefaction which had been produced was due to the contained ferment having peptonised the gelatine, and not to bacterial growth.

To test the accuracy of this supposition subcultures were made from the liquefied gelatine, with the result that the subcultures remained in every instance sterile.

To remove all possibility of doubt gelatine in a series of tubes was rubbed over with a sterilised platinum loop carrying a drop of pancreatic extract removed from the stock bottle. In every instance the gelatine in these tubes rapidly liquefied (the whole contents of the tube becoming liquid in the course of from 5 to 10 days). But the liquefied gelatine remained in every instance perfectly clear, and plate cultivations and subcultures made with portions of this liquefied material showed no evidence whatever of growth.

The glycerine extract inoculated upon agar;

Agar tubes were also inoculated with drops of the original pancreatic extract, and were kept in the incubator at a temperature of 37° C. They too showed no evidence of growth of any kind, and no liquefaction.

and into broth.

The experiments were now extended to broth tubes; and it was found to be a simple matter to remove with a capillary pipette a number of drops of extract from the stock bottle, to transfer them carefully to a broth tube, and to demonstrate the fact that the broth so inoculated remained for days and weeks after inoculation perfectly clear and free from any evidence of bacterial growth.

This result had not been anticipated; for the pancreas had in the first instance been allowed to stand (under a bell-jar) for 24 hours, and neither the instruments employed in cutting it up and mixing it with the glycerine, nor the bottle in which it was finally placed, had been in any way sterilised. Glycerine in bulk is, of course, an unfavourable

medium for the growth of saprophytes, still it had not been expected that the large number of micro-organisms which must have been present in the minced-up pancreas would have all been destroyed. And although the extract was sterile, it nevertheless possessed, as has been seen, the property of rapidly converting starch into sugar, and also of rapidly liquefying gelatine.

Thus there appeared a possibility of studying the action of the pancreatic ferment altogether apart from any complicating phenomena induced by the presence with it of micro-organisms, and this is undoubtedly a matter of considerable importance in connexion with the alterations undergone by food stuffs in the small intestines. For it has been recognised of late years that micro-organisms probably play an important part in breaking down the highly complex elements of the food; not in the stomach where the acid reaction of the contents can inhibit bacterial growth, but in the small intestines where the reaction becomes alkaline, and where micro-organisms (as is well known) abound. The question therefore has arisen as to how far the so-called pancreatic digestion is due to the ferments of the pancreas, and how far due to micro-organisms?

The action of the ferment of the gastric juice is readily studied experimentally, altogether apart from any complications induced by putrefactive organisms; all that is necessary is to add some pepsin to the material to be digested, and to render the mixture slightly acid by adding dilute hydrochloric acid. But in the case of the pancreas a difficulty at once presents itself, since the pancreatic ferment acts only in an alkaline medium, and in an alkaline medium bacteria can flourish.

It is clearly practicable, however, by adopting the plan detailed above, to study the action of pancreatic ferments apart from any coincident growth of micro-organisms. And the matter may be worth following up.

This much may here be said, that in none of the broth tubes to which pancreatic extract was added did any unpleasant smell develop; and this is a point of some interest in connexion with the suggestion which now arises that the business of the pancreatic ferments terminates with the conversion of proteid into peptone. Indeed if the further splitting up of peptones, which is usually spoken of as belonging to pancreatic digestion, be, as matter of fact, a consequence of bacterial activity, and not due to pancreatic ferments at all, then clearly the pancreatic extract described above when added to broth should not produce indol so long as the broth remains sterile; and hence the interest attaching to the fact that no substance possessed of the characteristic odour of indol was produced in the experiments detailed above in which the action of pancreatic extract upon broth was made the subject of observation.

To return, however, to the more immediate subject of this investigation.

As to inhibitory influence of the pancreatic ferment upon the growth of micro-organisms.

It was now anticipated that by adding the pancreatic extract already mentioned to nutrient materials and then subsequently inoculating them with various kinds of bacteria, it might be practicable to show that the extract possessed the power of inhibiting the growth of, or even that it actually destroyed, the germs introduced.

A large number of experiments were made with the view of putting this matter to the test, and two kinds of nutrient material were employed:—

Firstly, broth to which pancreatic extract had been added; and secondly gelatine, which had been liquefied by the action of this extract.

Several varieties of bacteria were in this way experimented with; among others anthrax rods, pneumonia bacillus, and the bacillus of Gaffky (typhoid bacillus).

The results obtained were, however, in the main negative. That is to say, the various species of bacillus introduced readily flourished, for the most part, in spite of the presence of pancreatic extract in the culture fluids.

The experiments were conducted in all instances on the principle of comparing the growth in cultures to which pancreatic extract had been added with the growth which occurred in control tubes. In some cases a few drops of pancreatic extract were added to a culture tube, and the same number of drops of boiled pancreatic extract were added to a control culture tube. Both tubes were then inoculated with a particular species of micro-organism. In other cases an amount of glycerine was added to the control tube equal to the amount of pancreatic extract added to the other tube, and both tubes were then inoculated with the same species of micro-organism.

In some of these experiments, notably in a series conducted with anthrax rods, there was apparently some inhibition of growth in the tube which contained the unboiled ferment of the pancreas, as compared with the growth which occurred in the control tube. This phenomenon was not, however, constant, and it is therefore impossible to lay much stress upon it.

III.—Experiments with Fibrin Ferment.

In the first instance three attempts were made to procure a glycerine extract containing fibrin ferment according to the method of Schmidt. The extracts so obtained appeared, however, to possess but little, if any, power, when added to culture fluids, of inhibiting the growth therein of micro-organisms.

Moreover it was found practicable to obtain material which manifested much more actively, than did this glycerine extract, the property of inducing the formation of fibrin in suitable fluids. In the majority of the experiments therefore this second kind of fibrin ferment was employed.

The mode of preparing this second kind of material,—a modification of Gamgee's method of obtaining fibrin ferment from blood,—was as follows :—

Method of obtaining fibrin ferment.

Some ox blood was obtained and allowed to clot. The clot was then washed under the tap for some hours until it was nearly colourless. The fibrin so obtained was then allowed to remain for 24 hours in an 8 per cent. solution of common salt, being thoroughly shaken from time to time. This material was then filtered, and the filtrate was evaporated to dryness over a water-bath, the heat being never allowed to exceed 40° C. The resulting mass was next pulverised in a mortar, and a powder, henceforward alluded to as the powder, was thus obtained.

This powder was found to possess in an eminent degree the property of accelerating clotting when added to salted plasma, and of inducing fibrin formation in certain samples of hydrocele fluid.

In illustration of this statement, the result of an experiment made on November 17th may be adduced : Ox-blood sodium sulphate plasma was diluted with six times its amount of normal saline solution, and placed in a series of test-tubes. To four of these tubes a trace of the powder was in each instance added, other two tubes being reserved as control tubes. The whole set of six tubes were then placed in a water-bath, and incubated at a temperature of 40° C.

After the lapse of two hours the contents of the four tubes to which had been added traces of the powder, had set firmly into a jelly-like coagulum ; so that each tube could be completely inverted without any

escape of its contents. The contents of the two control tubes, on the other hand, remained quite fluid and free from clot.

It should be remarked that the reason why it was not practicable to deal with a *fluid* extract containing fibrin ferment such as is produced by treating washed blood-clot with brine (Gamgee's method), was that such an extract must needs contain innumerable micro-organisms. The powder produced by slowly evaporating such a brine extract was, on the other hand, practically sterile, and hence it could be added to culture fluids, and its power of inhibiting the growth of special kinds of bacteria could be tested, apart from the complicating phenomena which would necessarily result if a number of other and different germs had been added to the culture fluid at the time of adding the fibrin ferment-containing material. In point of fact, it was desirable that the material experimented with should possess two characteristics, viz. :—

That in the first place it should contain the ferment substance freed as far as possible from other substances; and that in the second place it should contain no micro-organisms, *i.e.*, it should be sterile.

The powder now in question satisfied both these conditions, whereas an extract made by Gamgee's method (as ordinarily understood) would only have satisfied the former of them.

The following experiments were made with the powder :—

A.—*Series of Experiments.*

Several pairs of broth tubes were inoculated each with a different kind of bacillus and incubated at 37° C. After the lapse of 24 hours about half a gramme of the powder was added to one of the tubes of each pair, the other tube in each instance being kept as a control tube.

The behaviour of the tubes was then carefully observed, and plate cultivations were made with the object of testing to what extent development of the particular micro-organism inoculated occurred.

As to power of the fibrin ferment to destroy bacterial life.

For example—two tubes were inoculated with the *typhoid bacillus* (Gaffky) on December 17th, on December 18th the specified amount of powder was added to one of them, and on December 19th a plate cultivation was made from each of the tubes in the following way :—

Three drops of the material from the tube were thoroughly mixed with 10 c.c. of sterile saline solution. Of this mixture, one drop was transferred to a gelatine tube, the contents of which, having been liquefied and shaken up to ensure thorough distribution of the material inoculated, were then poured out in a plate and allowed to set.

The plate culture made with material obtained from the broth tube containing ferment powder, developed some 3,000 colonies of typhoid bacilli; whereas the plate made in precisely the same way from material obtained from the control tube, developed some 10,000 colonies of the typhoid bacillus.

On December 21st, after further incubation, plates were again made from the same tubes in the manner above indicated, and as before the control-tube developed a considerably larger number of colonies than did the plate made from material obtained from the ferment-powder tube.

In the case of the *cholera bacillus* the phenomena observed were, in some of the experiments, still more suggestive. *E.g.*, the inoculation of broth tubes was made on December 17th, and the ferment powder was added to one of the tubes on the following day; plate cultivations of each being subsequently made in the manner already described. As before, the tubes were incubated at 37° C. In this instance a very striking result was obtained. The plate culture made after the lapse of four days (December 21st) from the control tube, showed several thousand

colonies: whereas that made from the ferment-containing tube developed only 36 colonies.

Many of the experiments conducted on these lines, however, did not yield evidence that the ferment was capable of actually preventing the growth of the bacteria experimented with.

B.—*Series of Experiments.*

As to inhibitory influence of fibrin ferment upon the growth of bacteria.

To a broth tube, about half a gramme of the powder was added. After thorough shaking so as to mix the powder with the broth, and after waiting for half an hour, the tube was inoculated with a trace of material containing a particular kind of micro-organism. At the same time an ordinary broth tube was inoculated with the same kind of micro-organism to serve as a control experiment. The tubes were kept in the warm incubator at 37° C, their behaviour was watched, and plate cultivations were made from them at intervals.

E.g. two tubes (a ferment powder-containing tube and a control tube) were inoculated with diphtheria bacillus.

After 24 hours' incubation, plate cultivations were made.

The plate-culture from the control tube developed 206 diphtheria colonies.

The plate culture from the other tube developed no diphtheria colonies; in fact nothing but three moulds.

Of course a few experiments of this kind prove but little. In order to show conclusively that the ferment powder possesses in a marked degree the power of inhibiting growth, a large number of experiments giving a positive result would require to be recorded. In many instances my experiments gave negative results; that is to say, the number of colonies which developed in the plate culture from the broth tube to which ferment powder had been added was not found to be markedly less than the number which developed in the plate-culture from the control tube. In fact, I cannot claim that the number of positive results was sufficient to quite exclude the possibility of their being attributable to mere errors of experiment.

Conclusions.

Thus, although in the case of the blood ferment there was more evidence of an inimical influence upon bacterial growth than in the case of the pancreatic extract, in neither instance was it possible to so arrange the details of an experiment as to demonstrate with certainty that the micro-organisms under investigation uniformly developed less freely in the presence of the ferment than they did in a control tube to which ferment had not been added.

As regards saliva, however, a definite positive result was, as will have been seen, obtained; and this even when so resistant an organism as the bacillus subtilis was made the subject of experiment.

The most interesting outcome of this research is, no doubt, the fact that it appears to be feasible, in some cases at all events, to obtain material which is capable of manifesting ferment powers altogether apart from the coincident growth and development in it of micro-organisms. This observation may prove to be of service in the study of the action of unorganised as opposed to that of organised ferments; it appears indeed to be a first step towards the elucidation of the action of unorganised ferments upon bacteria.

No. 6.

Preliminary Report on the Growth of Bacteria in Pus; by F. W. Andrewes, M.B.

On the Growth of Bacteria in Pus; by Dr. F. W. Andrewes.

I have during the past year made a number of observations on the growth of different micro-organisms in pus.

Object of experiments.

The object of these experiments was to ascertain how far the material in question is inimical to their life and multiplication. If inimical, it must be owing to the chemical properties of the fluid, since in pus, and that in particular which has been kept outside the body, the leucocytes are effete,—in a state of fatty degeneration and incapable therefore of themselves exerting any active influence upon micro-organisms around them.

Methods.

In my first experiments I considered it necessary to sterilize the pus by discontinuous heat (exposure to 65° C. for one hour on several successive days); but this method soon appeared at fault, since it altered the consistency of the pus, and possibly affected also its chemical characters. I found too that sterilization was unnecessary, for it appears that pus is eminently unfavourable to the growth of many organisms, and is much less readily contaminated than ordinary culture media. For example, a pint or so of pus was aspirated from a psoas abscess with an ordinary aspirator which had been cleansed with 1 in 20 carbolic acid and then rinsed with hot water: from the aspirator the pus was poured into a large sterilized flask, which was then plugged with sterile cotton wool. Cultivations on agar-agar, and microscopic examination of stained specimens at the time of aspiration, showed the pus to be free from micro-organisms, and after some weeks it remained still free. Only at the end of some months had the pus in the flask acquired a sour smell, and was now found to contain numerous organisms of a kind which liquefied gelatine, and which had presumably got in on some occasion when the flask had been opened. I therefore ultimately adopted the method of receiving pus straight from an opened abscess or from an aspirating bottle, into a sterilized flask, sealing the latter with a plug of sterile cotton wool, and then as quickly as possible decanting the collected pus into a number of sterilized test tubes which were in turn duly plugged with sterile wool. Meanwhile cultivations and microscopic observations were made to ascertain what organisms, if any, were originally present in the pus. The pus tubes were then inoculated with the organism to be tested, well shaken, and cultivations made on agar-agar by dipping a platinum wire into the pus and smearing it over the surface of this nutrient medium. The wire removed roughly always about the same amount of pus, and the number of colonies that arose sufficed for a rough estimate of the abundance of the added organism in the pus at the outset of the experiment. Further cultures were made after 24–48 hours and at other stated intervals, and compared with the test cultures made at the commencement.

Source of the pus.

The pus which I have used was obtained from the following sources:—

(1.) A large abscess, probably of pyæmic origin, in connexion with the hip joint. In this pus the microscope showed a few streptococci; but they were apparently dead, as cultures remained quite sterile.

(2.) A chronic abscess of the back of two months standing. This pus contained no micro-organisms, either microscopically or by culture.

(3.) Acute phlegmonous inflammation of the cheek, with suppuration. This pus contained streptococcus pyogenes in large numbers; growing actively in pure culture on nutrient media, and not contaminated by any other organism.

(4.) A large chronic abscess of the thigh in connexion with sacro-iliac disease: the pus contained fairly numerous streptococci which grew freely in cultures; no other organisms were present.

Organisms tested.

The several micro-organisms thus tested as to their ability to grow in pus were:—Bacillus anthracis, sporing and not sporing. The hay bacillus (B. subtilis). The Proteus bacillus. Bacillus prodigiosus. Staphylococcus aureus, and Bacillus diphtheriæ.

And the results obtained were as follows:—

Bacillus Anthracis (recent non-sporing cultures).

1. Added to pus containing *no micro-organisms*.—A culture of this pus on agar-agar, made immediately after inoculation with the anthrax, yielded 21 anthrax colonies, and four colonies of some foreign organism. Similarly tested after 24 hours' incubation, no single anthrax colony appeared, but only four contaminating bacteria. The same pus tube which had been used for this experiment, together with a fresh pus tube, was heated for 10 minutes to 65° C., and both were then inoculated with non-sporing anthrax. After 24 hours' incubation cultures from the pus in both tubes remained sterile.

2. Added to pus containing *streptococcus pyogenes*.—A pus tube which had been standing for two days was inoculated with a 24-hours old broth culture of anthrax. A preliminary test culture of this pus yielded some 24 colonies of the anthrax organism; but tested after 24 hours' incubation no anthrax colonies grew, and streptococci were alone present. Later, a white staphylococcus appeared on culture, and its colonies became increasingly numerous day by day in samples of the pus. Thus the anthrax bacilli had all been killed in 24 hours, but the staphylococcus was able to multiply in the pus.

In the above experiments the pus tubes were incubated at a temperature of 37° C. In another experiment, a flask of pus from an acute abscess, crowded with living streptococcus pyogenes, was inoculated with material from a liquefied gelatine culture of anthrax, and incubated at 20° C. Cultures of the pus made after 24 and 48 hours yielded no single anthrax colony, and microscopic examination of the pus, after four days, showed only streptococcus pyogenes, and not a single bacillus rod.

3. Added to pus which had been *exposed to discontinuous heating*.—Two pus tubes were inoculated with blood from a guinea-pig just dead of anthrax, and which, therefore, contained no spores. Agar-agar cultures of this pus made after 24 and 48 hours yielded no anthrax colonies.

These results are all in harmony, and show that fresh human pus, whether sterile or containing streptococcus pyogenes, is fatal to non-sporing anthrax in 24 hours.

Sporing anthrax.

1. Added to pus containing *no micro-organisms*.—An agar-agar culture made immediately after inoculation of a pus tube with an old sporing anthrax culture, yielded 22 anthrax colonies. Twenty-four hours later a similar culture yielded no colonies; all were dead.

After a few days interval, this pus tube and another fresh one were heated for 10 minutes to 65° C., and then inoculated with sporing anthrax. Cultures made from them 24 hours later yielded no colonies.

2. Added to pus containing *living streptococci.*—An agar-agar culture made from a pus tube immediately after inoculation of the pus with an emulsion of sporing anthrax, yielded seven colonies of anthrax amongst the streptococci. After 21 hours' incubation a similar culture yielded only two anthrax colonies; after 48 hours, one colony only; and after three days, cultures yielded no anthrax colonies at all.

3. Added to pus which had been *exposed to discontinuous heating and then neutralised* with dilute acetic acid till it was only just alkaline.—A tube of this pus was inoculated from an old anthrax culture. After 24 hours' incubation, an agar-agar culture that had been made from it yielded four anthrax colonies; another, made after four days, gave a single colony only.

Thus, anthrax spores show little resistance to the action of pus; but, as might have been expected, are not for the most part so readily killed as non-sporing anthrax bacilli.

Bacillus subtilis (the Hay bacillus).

1. Added to fresh pus containing *living streptococci.*—A pus tube was inoculated from an old culture of the hay bacillus. Cultures were made on agar-agar immediately after inoculation; after 21 hours' incubation; and after incubation for two, three, and eight days. All showed equally profuse and abundant growth of bacillus subtilis; that occurring in a culture set going after eight days' incubation of the pus tube being as vigorous as at the outset of the experiment. Nevertheless, no multiplication of the bacillus was manifest in the pus.

2. Added to pus which had been exposed to *discontinuous heating*, the same results were obtained.

A pus tube to which acetic acid had been added till it was only just alkaline, was also inoculated from an old culture of the hay bacillus. Up to four days, agar-agar cultures from this pus gave an abundant growth of B. subtilis. No cultures were made therefrom after four days' incubation.

Thus, B. subtilis, though it does not appear actually to grow in pus, shows very great resistance to its action, and differs markedly in this respect from B. anthracis.

Proteus vulgaris (Hauser).

A single experiment indicated that this bacillus speedily died in pus. A pus tube which had been exposed to discontinuous heating and then nearly neutralised with dilute acetic acid, was inoculated from a culture of the proteus. No colonies appeared in an agar-agar culture of the pus made after 24 hours' incubation.

Bacillus prodigiosus.

This organism showed considerable resistance to the action of fresh pus. A tube of pus two days old containing living streptococci, and not in any way sterilised, was inoculated with the bacillus. Agar-agar cultures, made at once, and after the lapse of one, three, and six days' incubation, yielded equally abundant colonies of B. prodigiosus. But this bacillus showed no sign of growth in the pus; the colonies obtained from it were about as numerous after six days as at the outset.

Staphylococcus pyogenes aureus.

This organism showed similar resisting powers to B. prodigiosus. A tube of pus containing streptococcus pyogenes, two days old, was inocu-

lated from a liquefied gelatine culture of this staphylococcus, and agar-agar cultures were made from it at the usual intervals. The pus tube became, however, contaminated with a white staphylococcus, the colonies of which grew increasingly numerous. But after six days there were still many orange colonies amongst the others; *i.e.*, the staphylococcus aureus had held its ground, though it had not actually multiplied like the white staphylococcus which had got into the pus accidentally.

Bacillus diphtheriæ.

A tube of pus containing streptococci, two days old, was inoculated with an emulsion of a recent diphtheria culture. An agar-agar culture made immediately on inoculation, yielded two or three hundred diphtheria colonies, lying amid a multitude of streptococcus colonies. After two days' incubation a similar culture yielded many hundred diphtheria colonies, and no streptococci at all,—*i.e.*, the diphtheria bacillus had actually grown and multiplied in the pus. After the third day, a white staphylococcus got in and also multiplied in the pus, and by the sixth day its colonies were more numerous than those of the diphtheria organism, which, however, continued extremely numerous. Stained specimens of the pus at this stage showed the diphtheria bacillus in clumps; with clumps also of the staphylococcus, and a very few streptococcus chains.

It would thus appear that bacillus diphtheriæ differs from the other pathogenic organisms tested, in that it is able to grow and multiply in pus. But the matter requires further investigation.

Conclusions.

The above experiments show that, as might have been expected, different micro-organisms show very different degrees of resistance when inoculated into pus. Some, such as anthrax, die within 24 hours, or at the most (even if in the more resistant form of spores) within two or three days. Others are able to live longer, but show no sign of multiplication; while a third group, including staphylococcus albus and the diphtheria bacillus, are able to multiply in the pus. Many of these experiments require to be repeated, and many other organisms remain to be tested. It will further be important to ascertain if possible on what the bactericidal powers of pus depend; whether the liquor puris is as efficacious as the pus itself, and what effect the alkalinity of the pus has on its bactericidal properties. Some experiments which I have made indicate that feebly alkaline pus is less rapidly fatal to anthrax than ordinary pus; and others, that pus which has been heated to 65° C. loses none of its bactericidal powers. These matters I propose to investigate during the coming year.